Chapter VI.—THE DEVELOPMENT OF OIL TERRITORY.

In 1858 and 1859, just before Drake obtained oil in his well, the region now known as the "oil region" was an almost unbroken forest. Here and there along the valleys of the Allegheny and its tributaries the bottom-lands had been broken into farms, but on the hills, excepting in the neighborhood of the larger towns, there were but few cultivated tracts. The landscape along these winding streams was very beautiful. The towns were but little more than lumbering camps and trading stations, with few churches or school-houses, and the stores were for the most part kept by those engaged in the lumbering business, who employed nearly the entire population. This population traded a large proportion of the value of their earnings at the stores, and when the yearly settlements came they found a small balance due them. Those who were not engaged in rafting the lumber to Pittsburgh worked their small farms in summer and raised the small amount of produce required in the country, but in the winter lumbering was the engrossing occupation. Off the valleys of the main streams the roads were few and wretchedly poor. A few farms on the bluff southwest of Titusville had been occupied since 1798, and yet no public road had been built until some time after 1860.

After Drake's well was drilled, a demand arose for barrels and teams to haul the oil to points of shipment. This quiet and secluded region was invaded by adventurers from every direction, and the production of oil increased in volume so much more rapidly than the means of gathering and transportation that, although the production for the whole year of 1861 was only 1,035,668 barrels, less than the production of two weeks in 1880, the price fell in the fall of that year to 10 cents per barrel, and sales were reported as low as 6 cents per barrel. The influx of such an immense population into the villages and hamlets of this region taxed its agricultural resources to the utmost, and the construction of countless derricks, and the towns that were springing up like mushrooms along Oil creek and the Allegheny river, the making of tanks and thousands of barrels for storing and transporting the oil, gave a home market for the lumber of the country and stimulated an activity in business before unknown. Land along the creek supposed to be favorable for drilling purposes commanded fabulous prices; everybody had an interest in an oil-well; fortunes were suddenly made in one day and recklessly lost in another; and although railroads were pushed toward Titusville as rapidly as possible, the oil reached the surface faster than it could be disposed of, and was floated down the Allegheny river to Pittsburgh in bulk barges, many of which were broken up in the accidents of such navigation and the contents poured upon the stream. The valley of Oil creek became filled with derricks, and by 1863 the oil territory was supposed to be defined, when a daring prospector, having drilled a "wild-cat" well on the hills that border the valley, got oil, and wells were then spread over the hill country between Titusville and Tidioute. Meantime trunk lines had reached the valleys of the Allegheny and Oil creek, and the oil was moved out of the country.

The development of oil territory had mean time acquired a habit which has become well defined, and has been repeatedly exemplified during the last fifteen years. Commencing with the sinking of test or "wild-cat" wells outside the limits of any proved productive territory, the progress of such wells is eagerly watched, not only by those who pay for them, but also by many others who hope to profit by the experiment. While the experiment is in progress frequently all sorts of devices are resorted to to deceive others, not only to enable those engaged in the experiment to secure all the adjacent territory at favorable prices or leases, but also to prevent others from doing the same thing.

The striking of oil in a new well is the signal for a grand rush, as those who have territory to dispose of express extravagant opinions regarding the yield of the wells and the extent of the territory. A quiet country village at once becomes the center of a large business. Teams come pouring in with oil-well supplies, lumber, and provisions; a narrow-gauge railroad is projected and built with astonishing rapidity; corner lots are sold at fabulous prices; a speculative population floats into the place, the individuals of which come and go; and a common laborer to-day becomes a month hence a foreman, and in six months the owner of a well, and after a year is a gentleman of fortune. The quiet country town, too, with its modest school-houses and churches, takes on metropolitan airs and vices, and farmers become money-changers, the lucky ones who "strike ile" and do not lose their heads usually gathering together their thousands and leaving the overgrown village for New York or some other city. Some few remain and help to permanently improve the home of their childhood. Titusville, Oil City, Tidioute, Franklin, and Bradford are all examples of such towns. After a time the speculative phase is succeeded by that of settled and steady development, and the oil territory becomes outlined, the sagacious having secured control of the profitable tracts, and the floating population having by this time passed on to a new field, while their places have been filled by a more solid element, largely the moderately successful, because less reckless, who have come to stay. The influence of the floating and unsettled class is seldom salutary. In one instance that has been brought to my notice the most reckless system of public improvements was undertaken. School-houses greatly larger and more expensive than were necessary were built, and instead of being paid for by taxes levied on the oil that was then being taken from the ground, bonds were issued, payable at some future day, and left as a burden upon a community the extraordinary resources of which have long since been removed.

The development of the oil territory proceeds, after its existence has been demonstrated, without regard to any other interest. The derrick comes like an army of occupation. In the towns a door-yard or a garden alike surrender its claims. The farms, fields, orchards, or gardens alike are lost to agriculture and given to oil, and on the forest-covered hills the most beautiful and valuable timber is ruthlessly cut and left to rot in huge heaps wherever a road or a derrick demands room. Pipe-lines are run over the hills and through the valleys, through door-yards, along streets, across streets and railroads, and here and there the vast storage-tanks stand, a perpetual menace to everything near them that will burn. Nothing that I ever beheld reminded me so forcibly of the dire destruction of war as the scenes I beheld in and around Bradford at the close of the census year; and nothing else but the necessities of an army commands such a complete sacrifice of every other interest or leaves such a scene of ruin and desolation.

But the wave of desolation passes over, and nature changes the scene in the same manner as she gathers and restores the ruins of battle-fields. Along Oil creek, for the most part, the derricks have disappeared, and the brambles and the young forest are fast removing even a trace of their former presence. A visit to the famous Pithole City, which in 1865 was, next to Philadelphia, the largest post-office in Pennsylvania, showed a farmer plowing out corn where the famous Shearman well had been, a waving field of timothy where the Homestead well had been, the site of the famous United States well hardly to be found by one who had known it all through its career, and of the city there remained but fifteen or twenty houses, rapidly tumbling to decay, but not an inhabitant. The country around this scene of so much activity fifteen years ago is growing up to forest, and is not now valued at an amount equal to a year's interest on the valuation of that time.

Between the period of active development and absolute exhaustion comes the period of decay, when the derricks are rotting and falling to wreck, when property that has ceased to be productive has been sold at an extravagant price, and after accumulating debts has been abandoned. No one dares to claim the engine, boiler, and other tools, for fear he may become liable for the debts. Fine-engines go to ruin, and boilers are eaten with rust; small boys and idle men throw tools and pebbles in the well, and finally the vender of old iron comes along and carries off the junk to the foundery. At other times the owners of the well have made strikes somewhere else; and the well is then "pulled out" and all the machinery is carried to another field. Enormous quantities of material were carried from Oil creek to Clarion and Butler counties, and from there to the Bradford district.

The Oil creek region has now returned to the condition of an agricultural and manufacturing community, in which the production of oil is no longer the absorbing topic of conversation and the paramount interest. On the lower Allegheny, in Clarion and Butler counties, the production of oil has become much lessened in importance, and the wreck of abandoned derricks in many localities presents a dismal picture. The Bradford field is now in fully developed activity, and the destructive subordination of every other interest, and of all other considerations of ordinary value, is everywhere painfully apparent. With all this there is an evidence that so-called public improvements are only of a temporary character. The towns that are the result of the production of oil are scarcely more substantial than a military camp, and from lack of orderly arrangement, neatness, and sanitary regulations are far less inviting in their appearance. The railroads remind one forcibly of those built around Petersburg during the war, although they possess the elements of permanency to a greater degree, and the destruction of so much valuable timber produces a melancholy aspect.

The Allegheny district in New York is just opening up around Richburg, and all the phenomena peculiar to the first stages of an oil excitement are to be observed there.

It is not to be inferred, however, that any of the sections into which the oil regions have been divided have ceased to produce oil. There are wells now producing in sight of the spot where Drake drilled the first well; but large tracts of country cease to be the centers of speculative investment, and old wells to be remunerative, and the new wells no longer hold the possibilities of a grand lottery prize. It is the opinion that large areas in the Oil creek district will be redrilled and will produce in the aggregate large quantities of oil if the price ever reaches $2 a barrel. At present prices, the pumping wells of that district cannot successfully compete with the flowing wells of McKean county.

CHAPTER VII.—THE PRODUCTION OF OIL.

SECTION 1.—PRIMITIVE METHODS.

Oils and malthas appear to have been obtained in Persia from a very early period, but the methods employed were extremely simple. Most frequently the basin of the spring appears to have been surrounded by a stone coping, and sometimes it was covered with some sort of a niche or building, but often the oil was simply skimmed from the surface of the water which it accompanied. Herodotus describes the manner in which, by means of myrtle branches, the bitumen was obtained from the springs in Zacynthus, now Zante. It is, however, by means of dug wells or shafts that petroleum has been usually obtained in regions where the art of drilling artesian wells was unknown.

In Japan from a very remote period wells have been dug and tunnels have been run into hillsides for oil. Some of these abandoned drifts have caved in and large trees are growing upon them.

In relation to the manner of working these wells, B. S. Lyman, in his *Reports on the Geology of Japan*, 1877, says:

The present mode of working is very simple, a method that has probably grown into its present form in the course of centuries of experience, and is now apparently practiced in all the oil regions with little or no variation. The digging is all done by two men, one of whom digs in the morning from nine o'clock until noon, and the other from noon until three. The one who is not digging works the large blowing machine or bellows that continually sends fresh air to the bottom of the well. The blowing apparatus is nothing but a wooden box about 6 feet long by 3 wide and 2 deep, with a board of the same length and width turning in it upon a horizontal axis at the middle of each long side of the box, and with a vertical division below the board between the two ends of the box. The workman stands upon the board and walks from one end of it to the other, alternately pressing down first one end and then the other. At his first step on each end he gives a smart blow with his foot, so as to close with the jerk a small valve (0.3 foot square) beneath each end of the board, a valve that opens by its own weight when the end of the board rises. The air is therefore driven first from one end of the box, then from the other into an air pipe about 0.8 foot square, provided at top, of course, with a small valve for each end of the blowing-box, made of boards in lengths of about 6 feet, and placed in one corner of the well. The well is, besides, timbered with larger pieces at the corners and light cross-pieces, which serve also as a ladder for going up and down, though at such a time, in addition, a rope is tied around the body under the arms and held by several men above the mouth of the well. The earth or rock dug up is brought out of the well in rope nets by means of a rope that passes over a wheel 1 foot in diameter, hung just under the roof of the hut, about 10 feet above the mouth of the well, and is pulled up by three men, one at each corner of one side of the well, and the third in a hole two or three feet deep and a foot and a half wide dug along side of the well. * * * Wells are dug in this manner to a depth of from 600 to 900 feet, a depth at which great difficulty is experienced in securing sufficient light to carry on the work, which is often prosecuted only from nine a. m. to three p. m. These wells are dug about 3½ feet square. One well 900 feet deep is reported to have cost only about $1,000. The oil is skimmed from the surface of the water and drawn up in buckets.

In a letter dated Toungoo, British Burmah, September 14, 1881, Rev. J. N. Cushing, D. D., says:

At Yenangyoung the construction of the wells is after the most primitive method. The wells are dug about 5 feet square. A native spade for loosening the soil and a basket for conveying it from the well are the implements used. As fast as the well is sunk it is planked up with split, not sawed, planks. There are generally three or four men engaged in the work of digging, each one taking his turn. A man remains below with a large rope fastened about him. A small rope attached to a basket is used to draw up the earth, which is saturated with oil, and is often quite warm to the touch. Sometimes the gas is so strong as to prevent a person from remaining below more than a couple of minutes, and occasionally a man is drawn up quite insensible. The usual time of remaining down is about twenty minutes, when the man gives the signal that he wishes to be drawn up by jerking the rope. The yield is seldom very rapid, as I have never heard of any petroleum rising to the surface. Still some of the wells yield a large amount and then dry up. A windlass is built upon a frame over the well at a height of about 5 feet from the mouth. Over this windlass a rope is placed having a bucket at one end. The rope is not much longer than the depth of the well. The other end is fastened around the waist of a man or a woman, who generally has two or more half-grown boys or girls to help pull. As soon as the bucket fills, these persons start on a run down a well-beaten path until the bucket has come up so that the person standing by the well can empty it. The work is done by a class of people whose families have been allotted this work from time immemorial by the royal law. They are not slaves, but do not have permission to remove, and are considered as bound to work for the production of the royal monopoly.

In Galicia wells were dug as for water, and in some instances congeries of wells were united at the bottom by galleries, into which the petroleum filtered from the rock. The digging of these wells and shafts was frequently attended with considerable danger of suffocation with gas. M. Coquand mentions that at Damanostotin, in Moldavia, the pits or wells were dug 40 meters (131.2 feet) deep, and lined with sticks, woven in a manner resembling a military gabion. The petroleum is obtained in a bucket, to which a stone is attached for a sinker. This bucket is drawn up by a rope. (*a*) Petroleum was also obtained for many years in the valley of the Po from wells that were dug.

In the United States several different methods for obtaining oil were employed before wells were drilled. It is reported that shafts were found in the Mecca (Ohio) oil district, of the sinking of which all record or tradition has been lost. Since the curbed pits on Oil creek, Pithole creek, and other tributaries of the Allegheny have been proved to be of French origin, it is not unlikely that the old shaft at Mecca was also made by the French. An unsuccessful attempt to obtain oil in this way was made at Mecca about 1864, and another attempt to sink a shaft to the Venango oil-sand was made in 1865 in the bend of the Allegheny river, on the east side, below Tidioute.

It was about 16 feet square and a little over 100 feet in depth. It was a failure in respect to obtaining oil, for just before it was deep enough to reach the third sand, or oil-producing rock, an accident occurred which resulted in its abandonment. The foreman, who was an experienced miner, was seated over the mouth of the shaft, which was covered, in company with one or two of his laboring men,

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a B. S. G. F., xxiv, 518.

eating their dinner. As they lighted their pipes it was suggested that a lighted paper be dropped into the shaft to see if any gas was there. It was done, and an explosion followed which killed the foreman and some of his men. It [the well] was immediately closed, and work was never resumed. (*a*)

Other shafts were sunk on Oil creek, but as none of them were successful in reaching the Venango third sand, they were abandoned.

Professor Silliman, sr., in 1833, thus described the method employed for obtaining Seneca oil at the famous spring at Cuba:

A broad, flat board, made thin at one edge, like a knife; it is moved flat upon and just under the surface of the water, and is soon covered by a coating of petroleum, which is so thick and adhesive that it does not fall off, but is removed by scraping on the edge of a cup. (*b*)

Near Burning Springs, West Virginia, the oil was collected early in this century "by digging trenches along the margin of the creek down to a bed of gravel a few feet below the surface. By opening and loosening with a spade or sharpened stick the gravel and sand, which is only about a foot thick, the oil rises to the surface of the water, with which the trench is partially filled. It is then skimmed off with a tin cup and put up in barrels for sale. In this way from 50 to 100 barrels are collected in a season". (*c*)

Professor J. P. Lesley thus describes the method employed for collecting oil on Paint creek, Johnson county, Kentucky:

Here are to be seen the old "stirring places", where, before the rebellion broke out and put an end to all manner of trade in Kentucky, Mr. George and others collected oil from the sands by making shallow canals one or two hundred feet long, with an upright board and a reservoir at the lower end, from which they obtained as much as 200 barrels per year by stirring the sands with a pole. (*d*)

J. D. Angier, of Titusville, worked the springs on Oil creek for some years prior to 1859. He found the springs logged up 6 to 8 feet square and as many feet deep. He arranged a sort of sluice-box, with bars, that held the oil while the water flowed on beneath. In this way he obtained from 8 to 10 gallons a day of 36° specific gravity, which he sold at Titusville for medicine and for lighting saw-mills and the derricks of salt-wells.

Seneca oil was obtained for many years and in many localities by saturating blankets with oil and wringing it from them.

SECTION 2.—ARTESIAN WELLS—THE DERRICK.

ARTESIAN WELLS.

The Jesuit missionaries to China found there artesian wells in full operation. These wells were drilled for brine and natural gas, the latter being frequently accompanied by petroleum. The following extract from L'Abbé Huc's celebrated travels in China describes their method of drilling very deep wells:

They [the wells] are usually from 1,500 to 1,800 (French) feet deep, and only 5 or 6 inches in diameter. The mode of proceeding is this: If there be a depth of 3 or 4 feet of soil on the surface, they plant in this a tube of hollow wood, surmounted by a stone, in which an orifice of the desired size of 4 or 5 inches has been cut. Upon this they bring to work in the tube a rammer of 300 or 400 pounds weight, which is notched and made a little concave above and convex below. A strong man, very lightly dressed, then mounts on a scaffolding, and dances all the morning on a kind of lever that raises this rammer about 2 feet and then lets it fall by its own weight. From time to time a few pails of water are thrown into the hole to soften the material of the rock and reduce it to pulp. The rammer is suspended to a rattan cord not thicker than your finger, but as strong as our ropes of catgut. This cord is fixed to the lever, and a triangular piece of wood is attached to it, by which another man, sitting near, gives it a half-turn, so as to make the rammer fall in another direction. At noon this man mounts on the scaffold and relieves his comrade till the evening, and at night these two are replaced by another pair of workmen. When they have bored 3 inches they draw up the tube, with all the matter it is loaded with, by means of a great cylinder, which serves to roll the cord on. In this manner these little wells or tubes are made quite perpendicular and as polished as glass. * * * When the rock is good the work advances at the rate of 2 feet in twenty-four hours, so that about three years are required to dig a well. (*e*)

The first artesian well drilled in the United States, in 1809, has already been described, as also the gradual improvements in tubing wells and in stopping off the surface water with a seed-bag (page 6). Prior to 1858 a great many wells had been drilled for brine in the valley of the Ohio and its tributaries, with such additional improvements as rendered them very effective for this purpose. Steam-, horse-, and hand-power had been employed in drilling with equal success, the tools and general manipulation of the well being essentially the same. The drilling of wells with hand-power was accomplished by means of a spring-pole. For this purpose a straight tree, forty or fifty feet in length, was selected. After the branches were removed, the butt was secured in the ground in such a position that the pole extended at an angle of about 30° over the spot at which the well was to be bored. To the smaller end the tools were attached, and by the elasticity of the pole, as it was alternately pulled down and allowed to spring back, they were lifted and made to strike at the bottom of the well.

The drilling of wells for oil has long since outgrown the spring-pole age, the figures on Plate VI showing the successive steps by which this has been accomplished.

THE DERRICK.

When the location of a well has been decided upon a derrick or "rig" is built. This consists of the derrick itself and a small house for an engine, with the necessary foundation for both. For this purpose masonry is not used, but instead a very heavy foundation of timber. The owner of the well owns the rig, boiler, and engine. The contractor who drills the well owns the cable, bit, blacksmith's and other tools, and supplies fuel for the engine and the blacksmith.

a Letter of W. W. Hague, of Tidioute, to S. F. Peckham.
b A. J. S. (1), xxiii, 99.
d P. A. P. S., x, 40.
e *Travels in the Chinese Empire*, 1,300, Harper's ed., 1855.

The following list of rig-timbers embraces, first, the foundation timbers, which are frequently hewn, and, second, sawed timber. The plan of foundation timbers (Fig. 15) is drawn for square timber, but in a region like the northern field, where the wells are chiefly located in forests, these timbers are often hewn from the trees around the well:

HEWED RIG-TIMBERS.

	Inches.	Feet long.
2 derrick-sills, spotted	12	21
2 derrick-sills, spotted	10	21
2 derrick-sills, flatted	12	21
2 derrick-sills, flatted	10	21
3 mud-sills, faced	16	20
5 mud-sills, faced	16	12
1 main-sill, squared	18 by 18	30
1 sub-sill, squared	18 by 18	14
1 cross-sill, squared	12 by 12	12
1 samson-post, squared	18 by 18	14
1 jack-post, squared	16 by 18	14
2 bull-wheel posts, squared	10 by 10	10
1 engine-block, squared	20 by 20	8
1 walking-beam, squared	12 by 26	26
1 bull-wheel shaft, squared	14 by 14	14
2 pulley-blocks, squared	12 by 12	6
4 braces, squared	6 by 8	14
1 lever, squared	7 by 9	7

Equal to 7,800 feet board measure.

SAWED RIG-TIMBER.

	Inches. Feet.	Feet.
8 pieces	2 by 10 by 20 =	267
5 pieces	2 by 8 by 20 =	133
6 pieces	2 by 12 by 18 =	216
4 pieces	2 by 10 by 18 =	120
7 pieces	2 by 8 by 18 =	168
8 pieces	1½ by 8 by 18 =	144
4 pieces	1½ by 12 by 16 =	96
18 pieces	2 by 10 by 16 =	480
18 pieces	2 by 8 by 16 =	384
6 pieces	2 by 6 by 16 =	96
25 pieces	2 by 4 by 16 =	267
4 pieces	2 by 6 by 14 =	56
20 pieces	1 by 12 by 16 =	320
20 pieces	1 by 8 by 16 =	213
20 pieces	1 by 7 by 14 =	245
2-inch plank, 20 feet long		800
1-inch boards, 14 feet long		500
1-inch boards, 16 feet long		4,500
		9,005

The foregoing dimension timbers may be either pine or hemlock, the latter being used almost exclusively at the present time:

HARD-WOOD LUMBER (OAK OR MAPLE).

	Inches. Feet.	Feet.
7 pieces	2 by 8 by 16 =	149
1 piece	2 by 12 by 12 =	24
		173

Hewed timber	7,800
Sawed lumber	9,005
Hard lumber	173
	16,978

Total, 17,000 feet of lumber for a rig.

To put the rig together requires—

	Pounds.
10-penny nails	150
20-penny nails	25
30-penny nails	125
40-penny nails	10
	310

Bolts	13
Strap-hinges ....pair..	1

If the wheels for reeling the cable and sand-pump rope are not purchased separately, but are made with the derrick, there will be required:

32 arms for 2 bull-wheels.
104 cants of 3 feet 9 inches radius for 2 bull-wheels.
32 cants of 4 feet 6 inches radius for band-wheel.
8 cants of 3 feet 3 inches radius for tug-pulley.

HARDWARE (RIG-IRONS).

1 walking-beam stirrup, 2¾ inches by ¾ inch.
4 bolts for securing the same by a wooden cap to the walking-beam.
2 boxes for band-wheel shaft, babbitted, and each with 4 bolts.
1 band-wheel shaft 4 feet 6 inches long, 3½ inches diameter, with 1 crank, 14 to 46 inches stroke, 6 holes; 1 wrist-pin, 2⅝ inches diameter; 2 flanges, 24 inches diameter; 2 flanges, 20 inches diameter; 12 flange-bolts, 7 inches long, ¾ inch diameter; 5 steel keys for flanges and crank; 1 collar and set screw (not always used).
1 saddle for walking-beam.
4 bolts for same.
2 side irons, boxes and bolts for samson-post.
1 derrick-pulley, 20 inches in diameter.
1 walking-beam hook, to hold temper-screw.
1 sand-pump pulley.
2 gudgeons, with bands, for bull-wheel.

The derricks require each about thirty days of skilled and ten days of ordinary labor. During the census year they cost from $325 to $400, according to the cost of getting the materials to the place where the rig was to be built. At the same time a set of "rig-irons" cost from $75 to $100. A rig for winter use must be closed in, and therefore requires a larger outlay for 1-inch lumber. The increased expense, however, amounts to only a small sum.

Figs. 16, 17, and 18 represent plans and elevations of a full oil-well rig. As originally drawn, they were prepared by H. Martyn Chance from working plans furnished by J. F. Carll. They exhibit in great detail the construction of a "rig" suitable for drilling a well from 2,500 to 3,000 feet in depth. The following description is abridged from the report of the *Second Geological Survey of Pennsylvania*, Report III:

The mud-sills *a* (Fig. 15) are generally sunk in trenches where the nature of the ground admits of its being done. They have gains cut into them to receive the main sill *d* and sub-sills *e* and *e′*. After all have been put in place and leveled up, the keys or wedges *h* are driven, and the whole foundation is thus firmly locked together. The samson-post *k* and jack-posts *l*, *s*, and *r* are dovetailed into the sills and held by properly fitted keys, *h*, as seen in the side elevation (Fig. 16). The braces are all set in gains and keyed up, *no mortises and tenons being used in the structure*, the advantages of which are (1) greater strength; (2) the keys can be driven to compensate shrinkage; (3) the posts and braces are easily put in line and kept there; (4) the whole is easily taken apart for removal.

Referring to the horizontal projection (Fig. 17), it will be observed that the samson-post is placed flush with one side of the main sill, and the band-wheel jack-post is put flush with the other side. In this way the walking-beam will run parallel with the main sill. If the main sill is less than 24 inches wide, these posts must, in order to get a bearing upon it, be set toward the center of the sill, the effect of which will be to throw the derrick end of the walking-beam to one side of the center of the derrick, and thus throw the engine and running-gear out of line with it.

If, therefore, the main sill be less than 24 inches wide, it should be placed in position and the point marked on it where the center of the samson-post is to come; then mark also the point on which a perpendicular will fall from the center of the wrist-pin. The dimensions of samson-post and band-wheel irons, with the length of the walking-beam, easily furnish these points, through which a chalk-line should be snapped, and all the work squared to this line. This throws only the main sill out of square with the other work. On this account a slightly crooked stick is found serviceable for a main sill.

A great variety of boilers are used, but the one in general use is a tubular boiler constructed very nearly on the plan of a locomotive boiler. Formerly the boiler was set up in the engine-house, frequently with the engine bolted on the top or side of it, or the whole thing was mounted on wheels; but the heavy drilling tools employed in the deep wells now drilled render a stationary engine necessary. The plan of drilling dry wells, now so universal, has been accompanied with so many fires and explosions by the ignition of gas at the boiler that prudence has caused the boiler to be removed to some distance from the engine and well. When near the oil-rock, it is now customary to remove both boiler and forge from near the derrick until the gas and oil are under control. A large boiler, centrally located, is sometimes used to supply steam to the engines of several wells that are being drilled simultaneously.

A 12 or 15 horse-power engine, *b′*, with a reversible movement, is bolted to the engine-block *b* (Fig. 16), and by means of its driving-pulley carrying-belt, *o o*, communicates motion to the band-wheel *m*, and through it to all parts of the machinery. The throttle-valve *l l* is operated by a groove vertical pulley. From this pulley an endless cord, called "the telegraph", extends to the derrick and passes around a similar pulley, *n n*, fixed upon the headache-post *z*, within easy reach of the driller. The driller has thus an easy control over the throttle-valve, and can stop and start the engine or increase or decrease its speed without leaving his position (Fig. 16). The reverse link *pp* is also operated from the derrick by the cord *q q*, which passes over two pulleys, one of which is fixed in the engine-house and the other on the derrick. A slight pull raises the link and reverses the motion, which is restored as soon as the cord is released and the link drops back.

The band-wheel *m* receives its motion direct from the driving-pulley of the engine, to which it is connected by the belt *o o*. On or near the end of its shaft *o* is the bull-rope pulley *n*, and upon its other end is the crank *o'*. This crank has six holes to receive an adjustable wrist-pin *p*, which is easily moved from one hole to the other to regulate the length of stroke required in drilling or pumping. As the band-wheel communicates motion through the pitman *q* to the walking-beam while drilling; to the bull-wheels, by the bull-rope *r r*, while running up the tools; and to the sand-pump reel, by the friction pulley *w*, while sand-pumping, all of which movements are used separately, the machinery is so constructed that the connections may be rapidly made and broken. The sand-pump reel *w* is put in motion by pressing on the lever *v*, which is joined by the connecting-bar *u* to the upright lever *t*. This brings the face of the beveled pulley *w* into contact with the face of the band-wheel. The sand-pump descends by gravity and is checked in its motion by pressing the lever *v* back in such a manner as to throw the friction-pulley *w* against a post, which acts as a brake. The sand-pump line is a cable-laid rope, seven-eighths of an inch in diameter, and is coiled upon the shaft *x*, from which it passes over the pulley *i i*, and thence to the well mouth. The most common sand-pump is a plain cylinder of light galvanized iron, with a bail at the top and a stem-valve at the bottom. It is usually 6 feet long, but is sometimes 15 or 20 feet in length. As the valve-stem projects downward a few inches beyond the bottom, it is only necessary to let it rest on the bottom of the waste-trough in order to empty it. Other forms of sand-pumps are more complicated in construction.

The walking-beam connections cannot be interrupted without stopping the engine. When disconnected, it is tipped at an angle of about 25°, which throws the derrick end back about a foot from its perpendicular over the well, and thus removes it from interference with cables, tools, sand-pumps, etc., as they are run up and down. The headache-post receives the walking-beam in case the wrist-pin should break or the pitman fly off. It is about 8 inches in section, and is placed on the main sill, directly under the walking-beam, in such a manner that in case of accident the walking-beam can fall only a few inches. (*a*) Fig. 19 shows the interior of a closed derrick at night, with the use of the temper-screw and derrick light.

SECTION 3.—THE DRILLING-TOOLS.

The illustrations given in this report are only those of the ordinary drilling-tools. The tools used for "fishing" other tools, broken or lost anywhere from 100 to 2,000 feet from the surface, are too numerous even for mention. These tools are of all kinds, from the delicate grab, designed to pick up a small piece of valve-leather or a broken sucker-rod rivet from the pump-chamber, to the ponderous string of "pole-tools" containing tons of iron, which, at a depth of 1,500 feet or more, can unscrew a set of "stuck tools" and bring them up piece by piece, or cut a thread on the broken end of a sinker-bar or an auger-stem, to which tools can be screwed fast, so that it may be loosened by the use of "whisky jacks" at the surface. (*b*)

A string of drilling-tools is represented together in Fig. 5, Plate VI, and separately in Figs. 20 to 30. The string weighs about 2,100 pounds, and consists of two parts, separated by the jars. The lower portion, or drill, that delivers its blow downward and cuts the rock, consists of the bit (Figs. 20 and 21), the auger-stem (Fig. 22), and the lower half of the jars (Fig. 23). The upper portion that delivers its blow upward consists of the upper portion of the jars (Fig. 23), the sinker-bar (Fig. 24), and the rope-socket (Fig. 25). The upper link of the jars, by delivering an upward blow upon the auger-stem and bit, prevents the bit from sticking and remaining fast, while the elasticity of the cable permits the motion of the walking-beam. The "jars" therefore become the center of importance as well as of action. They were invented in 1831 by Billy Morris, but were never patented. Fig. 23 shows a pair of jars closed and another opened, with cross-sections. They are made like two flat links of a chain, with a male screw attached to one link and a female screw attached to the other. The slots in the links are each 21 inches long, and the cross-heads 8 inches deep; there is, therefore, 13 inches of "play" to the jars.

J. F. Carll, in Report III, *Second Geological Survey of Pennsylvania*, page 299 *et seq.*, says:

> The manner in which the jars perform their work may be best explained, perhaps, in this way: Suppose the tools to have been just run to the bottom of the well—the jars closed as in *a*, Fig. 23—the cable is slack. The men now take hold of the bull-wheels and draw up the slack until the sinker-bar rises, the "play" of the jars allowing it to come up 13 inches without disturbing the auger-stem. When the jars come together they slack about 4 inches, and the cable is in position to be clamped in the temper-screw. If, now, the vertical movement of the walking-beam be 24 inches when it starts on the up-stroke, the sinker-bar rises 4 inches and the cross-heads come together with a smart blow, then the auger-stem is picked up and lifted 20 inches. On the down-stroke the auger-stem falls 20 inches, while the sinker-bar goes down 24 inches to telescope the jars for the next blow coming up. A skillful driller never allows his jars to strike on the down-stroke. They are only used to "jar down" when the tools stick on some obstruction in the well before reaching the bottom and in fishing operations. An unskillful workman sometimes "looses the jar" and works for hours without accomplishing anything. The tools may be standing on the bottom while he is playing with the slack of the cable, or they may be swinging all the time several feet from the bottom. If he cannot recognize the jar, he is working entirely in the dark; but an expert will tell you the

a J. F. Carll, Rep. III, *Sec. Geo. Surv. Penna.*, chap. xvii.

b Ibid., p. 298.

moment he puts his hand upon the cable whether the drill is working properly or not. As the "jar works off", or grows more feeble, by reason of the downward advance of the drill, it is "tempered" to the proper strength by letting down the temper-screw to give the jars more play.

The temper-screw, Fig. 26, forms the connecting link between the walking-beam and cable, and it is "let out" gradually to regulate the play of the jars as fast as the drill penetrates the rock. When its whole length is run down, the rope clamps play very near the well mouth. The tools are then withdrawn, the well sand-pumped, and preparations made for the next "run". With the old-fashioned temper-screw a great deal of time was spent in readjustment, for it had to be screwed up by tedious revolutions of the clamps. But this delay is now obviated. The nut through which the screw passes is cut in halves, one half being attached to the left wing of the screw-frame, the other half to the right wing. An elliptical band holding the set-screw *a* passes around the nut. It is riveted securely to one of the halves, and the set-screw presses against the other half to keep the nut closed. The wings *b b* are so adjusted that they spring outward and open the nut whenever the set-screw is loosened. To "run up" the screw the driller clasps the wings in his left hand and loosens the set-screw; he then seizes the head of the temper-screw in his right hand, and, relaxing his grip upon the wings, the nut opens, when he quickly shoves the screw up to its place, again grips the wings and tightens the set-screw.

The dimensions of the different tools required to make up a set are given in the figures that represent them. The lengths of the different parts are given below:

	Feet.	Inches.
Rope-socket	3	6
Sinker-bar	18	0
Jars	7	4
Auger-stem	30	[illegible]
Center-bit	3	3
	62	1

The wings of the temper-screw are $1\frac{1}{2}$ inches by $\frac{5}{8}$ inch, and 4 feet 6 inches long. The screw is $1\frac{3}{8}$ inches in diameter and 4 feet long, with two square threads to the inch. The weight of the string of tools is as follows:

	Pounds.
Fig. 25.—Rope-socket	80
Fig. 24.—Sinker-bar, $3\frac{1}{2}$-inch	540
Fig. 23.—Jars, $5\frac{1}{2}$-inch	320
Fig. 22.—Auger-stem	1,020
Fig. 21.—Bit	140
	2,100

The other tools weigh as follows:

	Pounds.	
Fig. 26.—Temper-screw	145	
Fig. 23.—Jars, 8-inch	565	
Fig. 20.—Two bits, 8-inch	320	
Fig. 30.—Reamer	180	
Fig. 21.—Two bits, $5\frac{1}{2}$-inch	280	
Fig. 29.—Reamer, $5\frac{1}{2}$-inch	140	
Fig. 27.—Ring-socket	50	
Fig. 28.—Two wrenches	210	
		1,890
Total weight of set		3,990
Total cost of set		$700
Driller's complete outfit, including cable, costs about		900

These tools are made of the best of steel and Norway iron.

Section 4.—DRILLING WELLS.

By reference to Chapter I, page 6, it will be observed that the Ruffner Brothers "provided a straight, well-formed, hollow sycamore tree, with 4 feet internal diameter, sawed off square at each end". This was placed on end, and by digging out beneath it was gradually sunk to the bed-rock. This device was in time replaced by a smaller conductor, that was placed in the center of a sort of shaft or well that was dug (when practicable) to the bed-rock. This conductor was made of two-inch plank spiked together, 6 or 8 inches square on the inside, and placed in position vertically beneath the center of the derrick floor, as shown in Fig. 1, Plate VI, and Fig. 31. When the bed-rock is below a depth to which it is practicable to dig, an iron pipe is driven to the rock (shown in Fig. 3, Plate VI, and Fig. 33). When the "drive pipe" is to be inserted a "mall" and "guides" must be provided. This mall is made of any tough, hard log that will dress 15 to 18 inches square and 10 or 12 feet long. Two sides only are dressed, one end being encircled by a heavy iron band, to prevent its splitting, the other having a strong staple driven into it, in which to tie the cable. Two pairs of wooden pins are put into each of the dressed sides, one pair near the top, and the other near the bottom. They are two inches apart and two inches long, the guides fitting between them. The guides consist of two 2-inch planks, placed perpendicularly upon a line drawn through the center of the well at right angles to the walking-beam, and 15 or 18 inches apart. They are securely stayed and strengthened by having narrower plank nailed on both sides of them, leaving their edges projecting 2 inches toward each other, to enter between the pins on the mall.

The well is started by spudding. To do this a short cable is run up over the crown pulley in the top of the derrick. One end is attached to the ring-socket (Fig. 27) and screwed to the auger-stem; the other is passed around the bull-wheel shaft two or three times and the end left free. The bull-rope is now put on and the engine started. A man in front of the bull-wheels seizes the free end of the rope coiled around the shaft, a slight pull causes the coils to tighten and adhere to the revolving shaft, and the auger-stem rises in consequence, until it hangs suspended on the derrick, when it is swung over the spot where the well is to be started. The engine is kept running and the bull-wheels continue to revolve, but the man holding the shaft-rope has full control of the tools. When he pulls on the rope the coils at once "bite" the revolving shaft and the tools rise; but when he gives his rope slack they fall, and so long as the coils remain loose upon the shaft it revolves smoothly within them and communicates no motion. Thus, by alternately pulling and slacking the rope, this animated substitute for a walking-beam raises and drops the tools as much or as little as may be required, while the driller turns the drill to insure a round hole.

After spudding awhile to prepare the way for the drive-pipe, the drill is set aside, and the pipe to be driven, armed at the bottom with a steel shoe, as shown in Fig. 3, Plate VI, is put in place.

The following graphic description of the drilling of a well is given by J. F. Carll, in Report III, *Second Geological Survey of Pennsylvania*, page 306:

The mall is attached to the spudding cable and let down between the guides, where it is alternately raised and dropped upon the casing or drive-pipe by the man at the bull-wheels, precisely the same as in spudding. The casing used is of wrought-iron, screwed together in thimbles the same as tubing. A heavy cap of iron is screwed in the top when driving, to prevent its being injured by the blows of the mall.

When two or three hundred feet of pipe are to be driven, as is frequently the case in some of our northern valleys, it requires a great deal of skill and judgment to put it in successfully. In these deep drivings, after a sufficient depth has been reached to admit of the introduction of a string of tools, they are put in and operated by the walking-beam in the usual way; the cable (a short one, furnished for the purpose) being coiled upon one end of the bull-wheel shaft, while the other end is left free to work the mall-rope on.

To facilitate the necessary changes, which must be made every time the drill is stopped and pipe driven, the lower part of the guides are cut and hung on hinges some 10 or 12 feet above the derrick floor, and when not in use may be swung up overhead out of the way of the workmen.

When a sufficient depth has been reached by spudding to admit of the introduction of a full "string of tools", the spudding machinery is abandoned.

Now the coil of drilling cable is rolled into the derrick and set upon end. The free end in the center of the coil is tied by a connecting cord to the rope just detached from the ring-socket, and by it drawn up over the crown-pulley and down to the bull-wheel shaft, where it is fastened; the bull-rope is put in place, the engine started, and the men carefully watch and guide the cable as it is wound, coil after coil, smoothly and solidly upon the shaft. When this is done the end of the cable depending from the crown-pulley is secured to the rope-socket, and the full set of tools is attached and swung up in the derrick. After carefully screwing up all the joints (the bull-rope having been unshipped), the tools (Fig. 5, Plate VI) are lowered into the hole by means of the bull-wheel brake *o o*, shown in Fig. 16. The band-wheel crank is then turned to the upper center; the pitman is raised and slipped upon the wrist-pin, where it is secured by the key and wedges; the temper-screw is hung upon the walking-beam hook; the slack in the cable is taken up by the bull-wheels until the jars are known to be in proper position; the clamps are brought around the cable (after a wrapper has been put on it at the point of contact) and securely fastened by the set-screw; the cable is slacked off from the bull-wheels, and the tools are now held suspended in the well from the walking-beam instead of from the top of the derrick, as before. Some fifteen or twenty feet of slack cable should be pulled down and thrown upon the floor to give free movement to the drill. When the drill is rotated in one direction for some time the slack coils around the cable at the well mouth; if it becomes troublesome, the motion is reversed and it uncoils. Only by this constant rotation of the drill can a round hole be insured.

Having now made all the necessary connections, it only remains to give the engine steam, and the drill will rise and fall with each revolution of the band-wheel and commence its aggressive work upon the rock below. From this point downward the daily routine of the work is very monotonous unless some accident occurs to diversify it. Day and night the machinery is kept in motion. One driller and one engineer and tool-dresser work from noon until midnight (the "afternoon tour"), and another pair from midnight until noon (the "morning tour"). Up and down goes the walking-beam, while the driller, with a short lever inserted in the rings of the temper-screw, walks round and round, first this way, then that, to rotate the drill. He watches the jar, and at proper intervals lets down the temper-screw as the drill penetrates the rock. When the whole length of the screw has been "run out", or the slow progress of the drill gives warning that it is working in hard rock and needs sharpening, he arranges the slack cable upon the floor so that it will go up freely without kinks, and informs the engineer that he is ready to "draw out".

After attending to the needful preliminaries, the driller throws the bull-rope upon its pulley, and quickly steps to the bull-wheel brake, while the engineer commands the throttle of the engine. The walking-beam and the bull-wheel are now both in motion, but at the proper moment one man stops the engine and the other holds the bull-wheels with the brake just when all the slack cable has been taken up, and the weight of the tools is thus transferred from the temper-screw to the crown-pulley.

This is a performance requiring experience and good judgment, for should any blunder be made a break-down must certainly result. To loosen the clamps on the cable and unlock the pitman from the wrist-pin and lower it to the main sill is but the work of a moment. Dropping the pitman raises the end of the walking-beam with the temper-screw attached to it and throws them back from their former perpendicular over the hole, so as to allow the cable and tools to run up freely without interference with them. Steam is now turned on again, and the tools come up. When the box of the auger-stem emerges from the hole the engine is stopped. A wrench is slipped on the square shoulder of the bit, and the handle dropped behind a strong pin fixed for that purpose in the floor; another wrench is put on the shoulder of the auger-stem; a stout lever is inserted in one of the series of holes bored in the derrick floor in a circle having a radius a little less than the length of the wrench-handle, and it is brought up firmly against the upper wrench-handle, thus making a compound lever of the wrench and greatly increasing its power. Both men give a hearty pull on the lever, which "breaks the joint", or, in other words, loosens the screw-joint connecting the bit with the auger-stem, so that the bit can be unscrewed and taken off by hand after it has been brought up above the derrick floor. The wrenches are then thrown off, steam is let on again, and the bit rises from the hole. Now the driller throws off the bull-rope by operating a lever with one hand, while with the other he catches the bull-wheel with the brake, holding the tools suspended a few inches above the derrick floor. At the same instant the engineer shuts off the steam, or else, suddenly relieved of its heavy work by unshipping the bull-rope, the engine would "run away" with lightning speed. It only remains now to hook the suspended tools over to one side of the derrick, and the hole is free for the sand-pump.

While the driller is sand-pumping the engineer unscrews the worn bit and replaces it by one newly dressed, so that there may be no delay in running the tools into the well again when sand-pumping is ended.

The "line" to which the sand-pump is attached (as before described) passes up over a pulley near the top of the derrick, and thence down to the sand-pump reel, which is operated from the derrick by means of hand-lever *v* and connecting levers *u* and *t*. While sand-pumping the pitman remains disconnected, the bull-rope lies slack on its pulleys, and the band-wheel is kept constantly in motion. A slight pressure on lever *v* brings the friction-pulley *w* in contact with the band-wheel, and the pulley immediately revolves, the slack sand-pump line is quickly wound up, and the sand-pump, which is usually left standing at one side of the derrick, swings out to the center and commences to ascend. Just now the lever is thrown back, and the connection between the friction-pulley and the band-wheel being thus broken, the sand-pump commences to descend into the well by its own gravity. If it be likely to attain too great speed in its descent, a movement of the lever to bring the pulley either forward against the band-wheel or backward against the brake-post will quickly check it, and thus the speed may be regulated at will.

As soon as the pump strikes bottom additional steam is given to the engine, and the lever is brought forward and held firmly, while the sand-pump rises rapidly from the well. The sand-pump is usually run down several times after each removal of the tools, to keep the bottom of the hole free from sediment, so that the bit may have a direct action upon the rock.

After the hole has been sufficiently cleansed, the sand-pump is set to one side, the drilling tools are unhooked, and, swinging to their place over the well mouth, are let down a short distance by the brake, the wrenches are put on, and the lever is applied to "set up" the joint connecting the replaced bit to the auger-stem. Then removing the wrenches, the tools are allowed to run down to the bottom under control of the bull-wheel brake. Connections are now made as before, the driller commences his circular march, the engineer examines the steam- and the water-gauges and the fire, and then proceeds to sharpen the tool required for the next "run", and thus the work goes on from day to day until the well is completed.

The derrick and other apparatus here described is that employed in the oil regions of Pennsylvania, where the wells are deep and the tools required for drilling them are heavy. In the Franklin, Mecca, and Belden districts the shallow wells require a comparatively simple and inexpensive apparatus, the derricks being often not more than 30 feet in height, and the entire cost of a well only about $300. In West Virginia and southern Ohio the "light rigs" of the early time are still largely used, but are gradually being replaced by the higher derricks, in which heavier tools and long lengths of pipe can be conveniently handled.

SECTION 5.—THE TORPEDO.

In 1862 Colonel E. A. L. Roberts, then an officer in the volunteer service, conceived the idea of exploding torpedoes in oil-wells, for the purpose of increasing the production. Having applied for a patent, in the fall of 1864 he constructed six torpedoes, and early in 1865 he visited Titusville to try his first experiment. The risk of damaging the wells prevented their owners from allowing the tests to be made; but Colonel Roberts finally persuaded Captain Mills to allow him to operate on the Ladies' well, on the Watson flats, near Titusville. The explosion of two torpedoes caused this well to flow oil and paraffine. This result produced great excitement, and led to the filing of several applications for patents and as many lawsuits for infringement, which were all finally decided in favor of Roberts. The complete success of the torpedo was not established, however, until December, 1866, when Colonel Roberts exploded one in the Woodin well, on the Blood farm. This well was a "dry hole", and had never produced any oil. The first torpedo caused a production of 20 barrels a day, and the second raised it to 80 barrels. This established the reputation of the torpedo on a firm basis. (*a*)

The following notice of the decision of Judge Strong, sustaining the patent of Colonel Roberts, explains the method of using torpedoes and the opinion of the inventor regarding their action:

The patent consists in sinking to the bottom of the well, or to that portion of it which passes through the oil-bearing rocks, a water-tight flask, containing gunpowder or other powerful explosive material, the flask being a little less in diameter than the diameter of the bore to enable it to slide down easily. This torpedo or flask is so constructed that its contents may be ignited either by caps with a weight falling on them or by fulminating powder placed so that it can be exploded by a movable wire or by electricity, or by any of the known means used for exploding shells, torpedoes, or cartridges under water. When the flask has been sunk to the desired position, the well is filled with water, if not already filled, thus making a water tamping and confining the effects of the explosion to the rock in the immediate vicinity of the flask and leaving other parts of the rock surrounding the well not materially affected. The contents of the flask are then exploded by the means above mentioned, and, as the evidence showed, with the result in most cases of increasing the flow of oil very largely. The theory of the inventor is that petroleum or oil taken from wells is, before it is removed, contained in seams or crevices, usually in the second or third stratum of sandstone or other rock abounding in the oil regions. These seams or crevices being of different dimensions and irregularly located, a well sunk through the oil-bearing rock may not touch any of them, and thus may obtain no oil, though it may pass very near the crevices; or it may in its passage downward touch only small seams or make small apertures into the neighboring crevices containing oil, in either of which cases the seams or apertures are liable to become clogged by substances in the well or oil. The torpedo breaks through these obstructions and permits the oil to reach the well.

Judge Strong, in delivering the opinion of the court, said:

While the general idea of using torpedoes for the purpose specified is not patentable, the particular method of employing them invented by Mr. Roberts is patentable; therefore he is entitled to protection.

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a Abridged from Henry's *Early and Later History of Petroleum*, p. 257.

The material used now in the Pennsylvania oil regions is nitro-glycerine, which is manufactured for the purpose by the ton. This was first used in quantities of from 4 to 6 quarts ($13\frac{1}{2}$ to $20\frac{1}{4}$ pounds, equal to from 108 to 162 pounds of gunpowder). This amount was gradually increased to 20, 40, 60, 80, and even 100 quarts. When the well is ready to be "shot", word is sent to the torpedo company, and the canisters are prepared in sections of about 10 feet in length and 5 inches in diameter. These sections are made conical at the bottom, so that they will rest securely on top of each other. The nitro-glycerine is carried in cans that are placed in padded compartments in a light spring wagon, which is often driven over the roughest mountain roads with great recklessness. Arrived at the well, one of the sections of the canister is suspended by a cord that passes over a pulley and is wound upon a reel. The nitro-glycerine is poured into the canister until it is filled, and then it is lowered by the cord to the bottom of the well. Another section is filled and lowered in like manner until the proper amount is put in place. Then the cord is drawn up and a piece of cast-iron weighing about 20 pounds, and made of such a form that it will easily slide down the bore, is allowed to drop down upon the cap, which is adjusted to the last section that was lowered. At a depth of 2,000 feet no sound reaches the surface, although 80 quarts of nitro-glycerine, equal to 2,160 pounds of gunpowder, may have been exploded by the hammer. After from three to ten minutes has elapsed a gurgling sound gradually approaches the surface, and the oil, welling up in a solid column, filling the bore-hole and mounting higher and higher, falls first like a fountain, and then like a geyser, and forms a torrent of yellow fluid, accompanied by the rattle of small pieces of stone and fragments of the canister, in a shower of oil-spray 100 feet in height. In five or ten minutes it is all over; 25 or 30 barrels of oil have been thrown to the winds, and the derrick has been saturated with it, so that in a short time it becomes as black as ink and as combustible as tinder. In some instances but little oil escapes from the well, and sometimes none at all. The position of a torpedo just before explosion is shown in Fig. 31.

While not disputing that in some instances the theory of the action of torpedoes formulated by Colonel Roberts may explain such action, I am forced to the conclusion that when a torpedo is exploded in such rock as the Bradford oil-sand the crushing effect of the explosion is comparatively limited. The generation of such an enormous volume of gas in a limited area, the walls of which are already under a very high gas pressure, and which is held down by a motionless column of air of 2,000 feet (the use of water tamping has been abandoned), must be followed by an expansion into the porous rock that drives both oil and gas before it until a point of maximum tension is reached. The resistance then becomes greatest within the rock, and, reaction taking place, oil and gas are driven out of the rock and out of the well, until the expansive forces originally generated by the explosion are expended. By this reaction the pores of the rock are completely cleared of obstructions, and the pressure of the gas within the oil-rock continues to force the oil to the surface until it is no longer sufficient for that purpose.

It is found that in shallow wells of only a few hundred feet in depth, like those of West Virginia, nitro-glycerine is not as efficient as gunpowder, the violent action of the nitro-glycerine throwing the column of air or water out of a well of that depth, while gunpowder is held down.

The expense incurred by using torpedoes in wells under the Roberts patent has led to many attempts to escape it, and many parties manufacture nitro-glycerine in the oil regions and explode it in wells by stealth. Such torpedoes are called "moonlighters". Another and more safe method is to purchase two-thirds or three-fourths the amount of nitro-glycerine required of outside parties, say 40 quarts for a 60-quart charge, and then engage the torpedo company to put in the other 20 quarts and fire it off, thus avoiding the payment of the royalty on the 40 quarts. These are called "setters".

The value of torpedoes in individual cases is unquestioned; but, as a whole, their value to the oil interest is doubtful. Some very remarkable instances are on record where the yield of a well has been greatly increased by their use. The Mathew Brown well No. 6, in Fairview township, Butler county, Pennsylvania, is said to have yielded an increased production of 300 barrels the first twenty-four hours, and this from a charge of only 4 quarts. Another instance is on record where a torpedo in one well increased the flow in a second well 80 rods distant so that the yield did not run down to its former amount for six months. It is, however, the opinion of those whose long experience well qualifies them to judge that, especially in close sand, torpedoes are of very little use. By some they are no longer employed. It is manifestly a destructive method of operation that yields quick results, attended with great waste.

SECTION 6.—LOCATION OF WELLS.

The production of petroleum is in a general sense a speculative business. It may, however, be conducted as a regular business, involving the sagacious use of capital in such a manner as experience and judgment would dictate, with due account as to its elements of uncertainty. Conducting their affairs on such a basis, there are large corporations and individuals who command large capital and who control large tracts of proved productive territory either in fee or under leases. There are also many adventurers, who, either alone or in company with others, drill wells as they might purchase lottery tickets, losing little if they prove dry and reaping a rich reward if they prove valuable. This latter class operate almost exclusively under leases. It would be impossible to give details of the varied conditions incorporated in leases, as they are cunningly drawn in favor of the lessee or lessor. The lease generally provides that the lessee shall drill a certain number of wells within a certain time and pay to the lessor, as a royalty, a certain proportion of the oil obtained, varying, according to circumstances, from one-tenth to one-fourth. As the reputation of territory improves, the undeveloped portion of a tract held under lease is subleased for a larger royalty or on a bonus, sometimes both. A tract originally leased on a royalty of one-eighth is subleased on a royalty of one-fourth, with perhaps a bonus of $300 an acre in addition.

The location of wells upon a given piece of land will depend upon circumstances; but I think it may be safely stated that, as a general rule, wells will be drilled along the border of a tract, rather than toward the middle. This is often to be regarded as a measure of protection, because if A does not draw as much as possible from B's territory, B is quite sure to drill a line of wells and draw from A. Wells have in many cases been located with a total disregard of all prudential considerations. In the valley of Oil creek, just above Oil City, leases of only a quarter of an acre were taken and wells drilled on them, thus insuring about twenty times as many wells as there ought to be, and reducing at the same time in a corresponding ratio the possibility of both continued yield and profit. On the Clapp farm, at the northeast end of this tract, good wells were struck, one of which, drilled in 1863, was pumping one barrel per day in 1881. Here the wells were not drilled close, but nearer the city six and even eight wells were drilled on an acre, and as a result nearly one-half of them were soon abandoned. Experience has proved that one well to five acres is as close as they should be drilled. The man who owns a lot has no safety but in getting his oil to the surface; for as long as his land remains undeveloped he is constantly exposed to the risk of having it sucked dry by the wells of his more energetic neighbor, and that is equivalent to disaster and financial ruin. If all the operators in a given district could be persuaded to enter a movement for suspending drilling, it would in the end be mutually beneficial; but in many instances lease-holders are compelled, either by the terms of their leases or by their own pecuniary embarrassments, to go ahead with development and realize as promptly as possible upon their investments.

SECTION 7.—THE OIL-SAND.

The character of the oil-sand has been easily studied from specimens thrown out by torpedoes. The Venango sand, extending from Tidioute to Herman station, in Butler county, is a conglomerate of small pebbles with large interstitial spaces. The depth or thickness of this sand varies from 10 or 12 to 125 feet at Triumph. When this great thickness was observed, the wells were drilled into the sand from 15 to 20 feet and pumped for a while, when it was discovered that they had not passed through the sand. On drilling through to the bottom the wells continued to produce for a long period. The Warren sand is fine-grained, bluish in color, and is inclined to be muddy, while the Bradford sand is a friable sandstone, somewhat coarse-grained, and is of a brown color.

The opinion formerly held respecting the occurrence of oil in fissures has been noted elsewhere (see page 18). It was not only held as a scientific hypothesis, but it exerted a very important practical influence on the methods employed for obtaining oil. At one time an instrument was very widely used for indicating the point at which a crevice occurred in a well, and torpedoes were introduced at such points. It cannot be denied that near the surface oil-bearing rocks do contain fissures. The Berea sandstone, where it comes to the surface at Berea, and the different members of the Venango oil-sand when they reach the surface, are fissured. The experience gained in drilling wells also shows the presence of fissures below the surface. Wells are sometimes started, and after passing through several strata reach one where, in spite of all attempts to remedy the evil, the hole will go crooked, the drill glancing from the rock on one side of the fissure, and the well, in consequence, has to be abandoned. At the same time the extent to which fissures exist in the deep beds of oil-sands is now believed to have been very much overrated. The experience gained in sinking deep wells leads rather to the conclusion that in them the drill penetrates a homogeneous solid sandstone, in the pores of which the oil is held under great pressure. Although oil is sometimes found in the joints of fractured slate or shale, the solid shale is nearly impervious, often to both oil and water, and is separated from the sandstone by a hard and wholly impervious shell or crust, which prevents the escape of the oil and gas. Sometimes, however, this crust is absent or is thin and soft, in which case oil is found in the sand-rock above; in other words, where oil is found in the second sand the crust of the third sand is not impervious.

The motion of oil laterally through the oil-sands is illustrated by numerous phenomena attending the drilling and operation of contiguous wells. It is observed that the wells and springs of water in the superficial strata fail when these strata are penetrated by deep wells. Even artesian wells sunk for water to the second sand are often drained by contiguous oil-wells sunk to the third sand in consequence of the lateral movement of the water through the second sand to the oil-well. It is asserted that the swampy section around Power's Corners, in the Mecca district, has been greatly improved by surface drainage through the numerous oil-wells that have been sunk in that neighborhood.

The capacity of a porous sandstone, or even of the coarse pebble conglomerate constituting the Venango third sand, to hold the vast quantity of oil that has poured forth from some wells has been questioned; but when we consider (1) the strong attraction existing between oils and dry surfaces, (2) the powerful capillary attraction exerted in consequence, and (3) the enormous pressure under which the oil is held in the rock and forced out when the reservoir is perforated, there seems to be no reasonable ground for doubting the sufficiency of such a source of supply. This opinion receives further confirmation from the large content of oil proved by Dr. Hunt to exist in the Chicago limestone (see page 63).

J. F. Carll has shown by experiment that the pebble sand will absorb from one-fifteenth to one-tenth of its bulk of oil, and, further, that "the aggregate sum of the pores or interspaces of a sand-rock of this kind, as exposed in the walls of a well of 5½ inches diameter, is equivalent to the area of an open crevice one inch wide, extending from top to bottom of the gravel bed, whatever its thickness may be". He further shows that "on Oil creek there is generally from 30 to 50 feet of third sand, and also from 15 to 30 feet of stray sand, both locally producing oil. Of this total, suppose only 15 feet is good oil-bearing pebble, we shall then have a producing capacity of 15,000 barrels per acre, or 9,600,000 barrels per square mile, which is adequate to the requirements of the most exceptional cases known". (*a*)

While the Warren and Bradford sands are quite dissimilar from the Venango sand, their porosity is sufficient to hold their content of oil.

The occurrence of so-called slush oil at North Warren and at Limestone, in the Tuna valley, has been attributed to fissuring of the sandstones and shales in such a manner as to allow the oil to rise into the fissures in the shales. These cases are local and exceptional, and are therefore not to be regarded as typical of the manner in which oil occurs generally.

SECTION 8.—THE MANAGEMENT OF WELLS.

Having shown how the oil-well is carried down upon a reservoir of sufficient capacity to contain a remunerative quantity of oil, it will next be shown how the well is managed after it is drilled and torpedoed. The present methods of management are the result of an historical progressive development, which will be best understood if discussed chronologically and in connection with the figures in Plate VI and the sections, Figs. 32, 33, 34, and 35. Figs. 1, 2, and 3, Plate VI, and Figs. 32, 33, and 34 were originally drawn by H. Martyn Chance, to accompany Mr. Carll's report, and were afterward redrawn by Miss Laura Linton, with some changes, to bring them into conformity with Fig. 4, drawn by Mr. Opperman. An examination of these figures shows the well divided into four sections, viz: the surface section, the bottom of the drive-pipe section, the bottom of the casing section, and the bottom section. These different sections show the arrangements at the derrick floor, at the bottom of the drive-pipe, at the bottom of the casing or seed-bag section, and at the bottom of the well. *Fig.* 1, *Plate* VI, and *Fig.* 32 show a well as arranged in 1861. It is the direct descendant of the well of the Ruffner Brothers, and was then in use around Tarentum and elsewhere for salt-wells. From the well-head at the derrick floor to the bed-rock was a plank conductor or drive-pipe, which held the loose sand or gravel of the drift. From the bottom of this conductor to the bottom of the well the rocks through which the drill had cut formed the walls of the bore, which was 4 inches in diameter. Within this 4-inch hole a 2-inch pipe was inserted, with the pump-barrel screwed to its lower end. At a point estimated to be below that at which the water infiltrating the surface rocks entered the well the "seed-bag" was fastened in such a manner as to stop off this water from entering the bore of the well below. The pump-barrel being securely screwed to a length of pipe, it was lowered into the well, and piece after piece connected, until the point at which the seed-bag was to be introduced was reached; then a bag of calfskin or buckskin was securely tied to the pipe immediately below a thimble to prevent it from sliding. This bag was filled with flaxseed, and the upper end was so insecurely tied that if the tube was raised the bag would turn and empty itself. It was then lowered and the pipe added joint by joint until the required amount was put in. Beneath the thimble, at the end of the last joint, clamps were placed and securely fastened above the head-block, which rests upon the derrick floor. As the seed-bag absorbs moisture it expands and fills the 4-inch hole so completely that all of the water above the bag is held and prevented from passing below. Of course this well is drilled wet, that is, full of water, no attempt being made to stop off this water until the oil is reached and the well is prepared for pumping. If for any reason it became necessary to withdraw this tubing, the seed-bag came with it, and the water flowed into the bottom of the well.

Fig. 2, Plate VI, and Fig. 33 show the well of 1868. At this time it had become customary, after sinking the conductor or cast-iron drive-pipe to the bed-rock, to commence a 5½-inch hole, which was continued to the bottom. The position of the seed-bag was then determined, and it was securely fastened to the lower end of a section of casing-pipe 3¼ inches inside diameter. This was lowered to the proper depth. The 2-inch tubing, with the pump attached, was then lowered to the proper depth and secured at the top with the proper clamp. This well was of course drilled full of water, as the water was not stopped off until the tools were drawn out and the casing inserted. Instead of the ordinary seed-bag, a patent packer was sometimes attached to the casing in place of it. This packer was formed by pressing a sort of leather cup over an iron ring that was a little smaller than the drill-hole and was fastened to the outside of the casing. The pressure of the column of water above held the leather firmly to the drill-hole when the oil was pumped from below. Sometimes, as is represented in the figure, both the cup-packer and seed-bag were used at the same time. A casing-head was screwed on, usually with one or two outlets for gas,

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a Rep. Sec. Geo. Surv. Penna., III, p. 252.

and the gas that escaped inside the casing and outside the tubing could thus be utilized as fuel; at the same time the casing-head took the place of the head-block and formed a support for the tubing. In this way the casing was made a permanent fixture, effectually stopping off the water and permitting the tubing to be introduced or taken out at pleasure.

Although this method of drilling and casing wells was a great improvement over those previously employed, it still presented two very grave defects: First, the well must be drilled full of water, and, second, the hole was larger than the casing, and accidents sometimes occurred, which made it necessary to draw the casing and let the water into the well. To remedy these defects the plan was adopted that is shown in Fig. 3, Plate VI, and Fig. 34. According to this plan an 8-inch iron pipe is driven to the bed-rock. An 8-inch hole is then carried down below the surface water. The drilling-bits are then made smaller, and the hole is contracted to 5⅝ inches. A second tube, armed with a steel shoe, is then carried down inside the drive-pipe, and ground in the tapering drill-hole to a water-tight joint. This casing thus effectually cuts off the water. The 8-inch jars and drills are exchanged for 5½-inch tools, and the hole is carried down from that point of the same diameter as the interior of the casing to the bottom of the well, with only water enough introduced to sand-pump properly. The buoyancy imparted to the tools and cable by 1,000 to 1,500 feet of water is thus avoided, and the presence of oil in any of the strata penetrated is immediately manifested by escaping gas and soiled tools, and sometimes by a gush of oil that fills and overflows the well before the tools can be withdrawn.

Mr. Carll (Report III, *Second Geological Survey of Pennsylvania*, page 320) estimates that "the average cost of drilling cased wells (especially if we take into account the reduced liability to accidents from tool-sticking, etc.) is probably little, if any, greater than it would be if they were drilled wet. Quite an item in the cost of fuel is sometimes realized, for a vein of gas may be struck several hundred feet from the bottom of the well, which will fire the boiler until the work is finished".

The advantage of having a hole of the same diameter all the way down is very great when fishing operations are necessary, and also when the packers which are now used are to be inserted. These are used in preparing the well for flowing, and their use is represented in Fig. 4, Plate VI, and Fig. 35, where a cased well, with tube and packer, are indicated in full operation. These packers are of rubber, and are so constructed that the tube within them moves in a sliding joint. The lower piece of pipe enters the bottom of the mass of rubber, and the upper section, being securely fastened to the upper portion of the mass, slides in the lower section in such a manner as to press with its whole weight against the rubber and force it against the sides of the drill-hole. A well prepared for flowing as represented in Fig. 4, Plate VI, and Fig. 35, and properly connected with a tank, will operate with very little attention for months. The flow will finally run down either from the exhaustion of the supply or the clogging of the pipes with paraffine.

The clogging of pipes with paraffine occasions a great deal of trouble in the Bradford district. This is occasioned, first, by the much larger percentage of paraffine in the Bradford oil, and, second, from the condensation of the less volatile and soluble paraffines, due to the very intense cold produced by releasing the oil from the high pressure under which it exists in the rock, and consequently rapid evaporation of the more volatile portions. No attempt has been made to ascertain accurately this temperature, but many incidental facts indicate that it is very low.

After a well has ceased to flow, and in those localities where the gas pressure is not sufficient to cause the oil to flow, the well is pumped. In the method of pumping represented in Fig. 1, Plate VI, and Fig. 32 the sucker-rods were introduced immediately after the pipe and seed-bag, and, after the seed-bag had had time to swell, connection was made with the walking-beam, and the water pumped out below the seed-bag. After this water was removed and its pressure taken from the rock the gas and oil entering the well were brought to the surface. With the adoption of the first method of casing wells (Fig. 2, Plate VI, and Fig. 33), the water was removed from the space between the casing and tubing, and the oil-rock being quickly relieved of its pressure, the oil and gas rushed in to supply its place, and after the removal of the water was brought to the surface. With the drilling of dry holes the method of pumping represented in Fig. 3, Plate VI, and Fig. 34 has been adopted. In this well there is no water to pump, and the oil is brought to the surface as long as any will enter the well. Sometimes so-called gas-pumps are applied to wells that have ceased to yield oil and a partial vacuum has been created, with the result of causing the oil to flow laterally into the well through the rock.

In some localities, where the oil is valuable and the yield of the wells small, as among the heavy-oil wells of the Franklin district or in the older portions of the Oil Creek district, a method of pumping wells by sucker-rod connections has been adopted. The use of sucker-rods was no doubt adopted on account of the fact that old rods were suitable, numerous, and cheap. An engine is attached to a circular horizontal table by an elbow-joint in such a manner that it is made to perform a quarter revolution and return to its former position. To the circumference of this table from two to a dozen or fifteen connections are made, in such a manner that each connection is given an equal stroke sufficient to move a pump connection, such as is represented in Fig. 36. The pull of the engine comes on the down-stroke of the pump, and the up-stroke of the pump is balanced by the stones or other heavy material placed in a box on the arm, *a*. The rods by which these connections are made for long distances are supported by light frames, which have a swinging motion as the rods move slowly to and fro. In the Franklin district, where the wells are shallow, the rods are made of strips of ash $2\frac{1}{2}$ inches square, nailed together by wooden straps. From thirty to forty wells are thus sometimes attached to one engine. In the White Oak district of West Virginia, where the ground is too uneven to admit of wooden connections, motion is communicated to a dozen or more wells by an endless rope, usually of wire, that is supported on wheels and runs up one hill and down another and along the valleys to a convenient site for the engine. By this method wells can be profitably pumped that would otherwise have to be abandoned.

At the Katie Hough well, on Mud run, in the White Oak district, West Virginia, in the summer of 1881, the curious phenomenon was exhibited of pumping two kinds of oil from the same well. In this region there are several oil horizons, and at the point penetrated by this well the first White Oak sand produces oil of 27° specific gravity, and third White Oak sand beneath it yields oil of 45° specific gravity. The well was in 1865 put down 255 feet to the first White Oak sand, and was pumped at intervals for 15 years; it was then reamed to an 8-inch hole, and a $4\frac{1}{2}$-inch hole sunk to the third sand. A tube, with a seed bag at the bottom of the 8-inch hole, was inserted, and the heavy oil stopped off. From this tube amber oil of 45° specific gravity is pumped from the third sand. A second pump and tube was then inserted in the 8-inch hole beside the other tube and proper connections made with the walking-beam, every stroke of which pumped dark, heavy oil of 27° specific gravity from the first sand, worth $7 per barrel, and amber oil of 45° specific gravity from the third sand, worth $1 per barrel. The Shaw well, on Gales' Fork, also in the White Oak district, said to have produced $80,000 worth of oil, pumps oil of 25° specific gravity from a depth of 160 feet and an oil of the specific gravity of 40° at a point between 600 and 700 feet.

It has been the custom around Titusville and Pleasantville, when the production of a well ran very low, to introduce into it five to ten barrels of crude naphtha (benzine), and after allowing it to remain for a few days to resume pumping, an increased production being the result.

The large amount of oil that has at different times and in certain localities run to waste upon the streams has been due to unavoidable waste, to the bursting of pipes and tanks, the sinking of barges, and to oil which has escaped destruction during extensive fires. On the Allegheny river at Oil City may always be seen a thin film of oil often sufficient to produce iridescence. The quantity of oil required to produce this effect, although apparently very small, is in the aggregate quite large. Where booms are stretched across such streams the floating oil is arrested and may be pumped from the surface with water into settling tanks and collected. In this way the collection of oil has been made a profitable business, as occasion might warrant, thousands of dollars' worth having been gathered in a single season that would otherwise have gone to waste. In 1862, 4,000 barrels were dipped from the Allegheny river and was used for lubricating oil and for making lampblack.

The occurrence of oil in the drift gravels beneath the superficial clays south of Titusville has already been mentioned (see page 49). The oil here was pumped from shallow wells, dug only a few feet into the gravel. (*a*)

SECTION 9.—YIELD OF WELLS.

The average duration of the profitable production of an oil-well is very uniformly estimated at five years, but this period is subject to very great variations. The wells in the Colorado district, northeast of Titusville, have been pumped about twelve years, and have yielded constantly enough to more than pay expenses. In the White Oak district of West Virginia the Scott and Scioto wells, drilled in 1865, were being pumped in 1880. On the contrary, the Cole creek portion of the Bradford field had all been drilled over since 1879, and some of the wells were abandoned before June 4, 1881, while at the same date wells were flowing near Tarport, in the same field, that were drilled in 1875. As a general rule, it may be said that the nearer the wells are to each other on a given piece of property the sooner they will become unprofitable.

As an illustration: On Triumph hill eight wells were drilled in a group, two on the edge of the belt and six nearer the center. As each well was drilled it commenced to yield at the rate those previously drilled were yielding at that time. The first well was drilled in 1866, and yielded an average daily production for the first six months of 70 barrels, the second six months 41 barrels, the second year 35 barrels; it then fell off gradually until it reached 5 to 7 barrels, where it remained for two or three years; it then continued to fall, until for the three years preceding 1881 the yield was only about 1 barrel a day. The eight wells were pumped with sucker-rods by one engine. The six central wells were 9 or 10 rods apart. The sand in the center of the Triumph belt is more than 100 feet thick.

The Economites drilled two wells on their tract upon the hill east of Tidioute 300 feet apart. They started at 100 barrels a day and held it three months, then ran down to 25 barrels in two years, and during the two years following ran down to 200 barrels a week and held about that yield for two years. Two wells were drilled in

a In the summer of 1881 quite an excitement was occasioned in Titusville by the discovery of oil saturating gravel beneath the soil of gardens along the creek. Several hundred barrels were pumped and dipped from holes or pits dug over an area of several acres. It was supposed to have been the leakage from loading racks during the Pithole development.

positions *a* and *b*. They started at 125 barrels each, and in eighteen months ran down to zero. The rigs were then changed to the other side of the engines at *a′* and *b′* and the wells were redrilled. They were drilled deeper into the sand the second time, and were cased with $5\frac{5}{8}$-inch instead of $3\frac{1}{4}$-inch casing. These second wells started off at 75 barrels a day and lasted ten years. The first wells were drilled by a man who had a hobby that 10 feet in the sand is sufficient, but the second wells were drilled through 25 or 30 feet of sand.

a *a′*

b′ *b*

The yield of some single wells has been enormous. One half of the Empire well was sold for $900, and it afterward yielded $12,000 in six days. Its owners saved 3,500 barrels a day and sold it for 10 cents a barrel. The owners of the land were unable to furnish barrels, and the royalty was put into pits dug in gravel. Well No. 4, on the Jacob and John Hemphill farm, Donegal township, Butler county, Pennsylvania, struck by McKinney Brothers in September, 1873, has produced about 110,000 barrels, and is still (1881) producing six barrels daily. The farm upon which this well is located is among the most prolific oil properties ever developed, twelve wells thereon producing over 750,000 barrels. The Divner well, No. 1, Divner farm, Butler county, Pennsylvania, has yielded about 200,000 barrels, and six years after being struck produced 13 barrels a day. The Boss well, on the J. A. Parker farm, in Armstrong county, Pennsylvania, produced about 80,000 barrels. The amount yielded by any one well in the Bradford district is much smaller, from 20,000 to 25,000 barrels being probably the highest yield.

SECTION 10.—FLOODING.

The proximity of other outlets appears to determine the duration of the flow of oil-springs or wells. The spring in the island of Zante is known to have flowed two thousand years. The Beatty well, in Wayne county, Kentucky, drilled in 1819, is still flowing, there being no other well near it. The American well yielded oil in large quantities from 1830 to 1860, but after the drilling of other wells in the neighborhood the yield fell off, and finally ceased altogether. It is therefore impossible for any producer controlling a small area to preserve his oil beneath the surface. The lateral flow of oil and water through the oil-sand has been repeatedly demonstrated. Jonathan Watson, in his experience, had known water to run into a well when the seed-bag was removed from another one-half mile distant, and in another instance red paint was put into one well and pumped out of another at about the same distance.

J. F. Carll, in Report III, *Geological Survey of Pennsylvania*, page 258, says:

The National well No. 1 was struck in February, 1866. It was very near the northwesterly edge of a large and well-stored pool, and passed through rather an inferior oil rock as compared with that afterward found on the axis of the belt. Still it had a sufficiently free connection with the supplying reservoir to furnish a delivery of about 85 barrels per day, and it maintained its production with wonderful constancy for two years, having only declined to about 60 barrels in that time. In the summer of 1868 wells were drilled on the center of the deposit from which it had been deriving its supply. Some of these wells produced as much as 150 barrels per day. The effect on the National was immediately apparent. Its production dropped off rapidly and dwindled down to 10 barrels or less a day. * * * Harmonia well No. 1 was on the thriving northerly edge of the Pleasantville belt. The main body of oil and the best sand-rock, as afterward demonstrated, lay to the south. It started with a small yield, and at the end of a fortnight was pumping about 30 barrels per day. Gradually increasing its production, as if enlarging and cleaning out the passages leading into the supplying reservoir, it finally commenced to flow, and ran up to 125 barrels, where it remained until wells of larger flow were drilled on the center of the belt and relieved the gas pressure, when pumping had to be resumed. After this it soon fell down to an unremunerative production and was abandoned.

The early method of drilling with the well full of water prevented the escape of the oil and gas until the water was pumped out; when the rock is pierced with a hole drilled dry "the effect is similar to the sudden liberation of the safety-valve of a boiler under a full head of steam, * * * "the boiling, foaming mass is driven upward against the forces of gravity", and sometimes shoots high above the top of the derrick. The equilibrium which had been maintained for ages throughout the communicating portions of the rock is suddenly destroyed in the immediate proximity of the well by this sudden rush up the drill-hole, and material gaseous at the ordinary temperature and pressure, but fluid under the enormous pressure maintained in the oil-rock, expands and evaporates as it rushes to the surface. This action goes forward, slowly reducing the pressure upon all the communicating portions of rock, until the pressure on the oil filling the rock is only equal to that of the column filling the drill-hole. The pump is now used to lift the fluid from the drill-hole, the oil being still under the pressure of the gas ascending between the tubing and casing. The rock is still full of oil, and the pumping goes on until the pressure of the gas is scarcely sufficient to send any of it to the surface, when a gas-pump is applied at the casing-head to one of the lateral tubes and the pressure of the atmosphere removed. Still, after all this has been done, there is oil remaining in the rock. As before intimated, the oil and gas mutually dissolve each other and form a homogeneous mass, "the gas being as thoroughly incorporated with the oil as gas is with water in a bottle of soda-water." The effects of "flooding" or allowing water to enter the rock partially exhausted of its oil has been the subject of much controversy. Some producers imagine that if the rock is properly flooded the oil can be driven toward certain points and removed to advantage, but experience has proved such operations extremely hazardous.

J. F. Carll has discussed this subject in great detail, and I am greatly indebted to his report and private conversations for information on this subject. He says: (*a*)

The first intimation of the flooding of a district is given by an increased production from the wells affected by it. Old wells improve gradually, running up from 5 to 10 or 20 or even 50 barrels. After pumping in this way for some time, the oil quickly fails, and they yield

a J. F. Carll, Report III, p. 265.

only a few barrels of salt or brackish water. * * * In some districts the movement is quite rapid, and wells are invaded and "watered out" in quick succession; in others it is so slow that large quantities of oil are obtained from those which are favorably located to receive a "benefit". Flooding a well is sometimes a very profitable way of closing up its career, inasmuch as it thus yields more in a few months than it otherwise would in years, and when the water reaches it the owner knows at once what it betokens and stops work, thus saving the time and money usually expended in fruitless efforts to reclaim a well failing through natural decline. * * * In judging of the probable effects of the introduction of water into any particular oil district several things are to be considered. (1) *The time of flooding,* whether early in the progress of development, while yet a large percentage of oil remains unexhausted, or at a later period, after the supply has suffered from long-continued depletion. (2) *The structure of the rock,* whether regular and homogeneous throughout, or composed of fine sand interbedding and connected and irregular layers of gravel, sometimes lying near the top and at others near the bottom. (3) *The shape of the area being flooded.* (4) *The position of the point at which water is admitted* in relation to the surrounding wells still pumping oil. (5) *The height* (which governs the pressure) *of the column of water* obtaining admittance. (6) *The duration of the water supply.* It will readily be seen that a *temporary flooding* of comparatively *fresh territory,* such as frequently occurred in early days along Oil creek, from the drilling of new wells without casing or the overhauling of old ones when the seed-bag was attached to the tubing in the primitive way, must necessarily be quite a different affair from one caused by a *permanent deluge* through unplugged and abandoned wells *in nearly exhausted territory.* In the former case the flood may be checked before much water has accumulated in the rock, and then the oil-flow can be reclaimed after a few days of persistent pumping; in the latter, the recovery of the oil is very uncertain, because from its long-continued extraction a greater capacity has been given to the rocks for storing water, and this being supplied from scattered and obscure sources, there is little probability that it can be shut off, although the most thorough and systematic attempts may be made to check it.

The effect of flooding upon adjacent wells is illustrated by the following incident related of the Oil Creek district: A and B owned wells 200 feet apart. A's pumped about 10 barrels a day and B's 30. B wished to pump his, but A thought his would not pay and stopped, when B soon found he could get only water. B offered A $10 per day to pump his well ten days. At the end of ten days A refused to pump, then B offered him $25 a day for twenty-five days, at the end of which time B offered A $30 a day to pump his well an indefinite period, and A consented. In the mean time the oil in B's well increased gradually until it reached 75 barrels a day, and the operation proved profitable.

This flooding of oil territory has been proved of such importance that the legislature of Pennsylvania has affixed a penalty to any neglect to "plug" abandoned wells. The plugging consists in filling them with sand. A moment's reflection will show that the owner of oil territory must have it drilled or it will be exhausted by his neighbors drilling a cordon of wells around his property. After it is drilled, the wells must flow until the pressure of gas is exhausted, or, as has been known in several cases, the casing and tubing will be thrown out of the well. A case is on record where the casing-head was anchored down with chains and the flow of oil arrested, yet the gas pressure tore away the fastenings and threw the casing out through the top of the derrick. After the oil has stopped flowing, if the well-owner does not pump, his neighbor's pumps will drain his territory, and if he "pulls out", the law compels him to fill his well with sand and ruin it forever, to prevent the public injury resulting from letting down surface water into the oil-sand. There is therefore no other alternative presented to the unfortunate possessor of oil territory but to drill and produce, whatever the price of oil may be.

CHAPTER VIII.—TRANSPORTATION AND STORAGE OF PETROLEUM.

SECTION 1.—EARLY HISTORY OF TRANSPORTATION.

But few facts have come within my notice respecting the transportation of petroleum among the primitive peoples that have used it. In Burmah it is placed in jars and transported in them about the country. The breakage of the jars and muck occasioned by the leakage is mentioned by Major Symes as one of the disagreeable adjuncts of the production in the neighborhood of Rangoon.

In this country the Seneca oil of the early days was transported in barrels or packed in bottles. Dr. Haggard, of Burkesville, Kentucky, very graphically described to me the incidents attending the trip which he took to Louisville with the first barrel of oil that was ever sent away from the American well. The odor of the oil was so pronounced that it attracted a great deal of disagreeable attention along the road, and many criticisms more emphatic than elegant were made by the passers-by and inhabitants along the route.

During the first years of the excitement oil was transported in 40 and 42 gallon barrels, made of oak and hooped with iron. Its penetrating character led those interested to coat the barrels on the inside with a stiff solution of hot glue, which forms a continuous lining, is elastic, and is not attacked by the oil. (*a*) Great difficulty has always been experienced in the transportation of crude oil in barrels, due to the fact that such oil invariably contains a trace of water, usually as much as 1 per cent., which, acting on the glue, causes the barrels to leak, and consequently a loss of oil. To remedy this difficulty, and also to decrease the labor of handling the oil, early in 1866, or possibly in 1865, tank-cars were introduced upon railroads entering the oil regions. Those first introduced consisted of an ordinary flat car, upon which were placed two wooden tanks shaped like tubs, each holding about 2,000 or 4,000 gallons to a car.

While this change in methods of transportation was taking place on the railroads, a corresponding one had grown up in river carriage. The difficulty of moving such enormous quantities of material by teams was almost insurmountable. Aside from its enormous weight and bulk, the very magnitude of the transportation, carried on as it was over roads badly and recently constructed, left them during a large portion of the year in an almost impassable condition. The mud was often limitless in extent and depth, through which waded the long trains of teams to Oil City and other points of shipment.

The following appears in Henry's *Early and Later History of Petroleum*, page 287:

> Arrangements were made with the mill-owners at the headwaters of Oil creek for the use of their surplus water at stated intervals The boats were towed up the creek by horses—not by a tow-path, but *through the stream*—to the various points of loading, and when laden they were floated off upon a pond-freshet. As many as 40,000 barrels were brought out of the creek on one of these freshets, but the average was between 15,000 and 20,000. At Oil City the oil was transferred to larger boats. At one time over 1,000 boats, 30 steamers, and about 4,000 men were engaged in this traffic. Great loss occurred from collisions and jams. During the freshet of May, 1864, a jam occurred at Oil City, which resulted in the loss of from 20,000 to 30,000 barrels of oil.

Bulk barges were also introduced on the Allegheny and Ohio rivers. These were constructed with more or less care, many of those first employed being of inadequate strength and too easily broken up in the vicissitudes of river travel. As now constructed, they are made 130 by 22 by 16 feet, in eight compartments, with water-tight bulkheads, and hold 2,200 barrels. They are still used to convey oil from the lower Allegheny to the refineries at Mingo, Wheeling, Marietta, and Parkersburg, and also to float the production from Burning Springs down the Little Kanawha to Parkersburg.

In 1871 the wooden-tank car gave place to the boiler-iron cylinder car of the present time. These are now used in transporting crude, illuminating, and lubricating oils and other petroleum products; also residuum and spent acid. They are much safer and stronger than wooden tanks, and the railroad companies require shippers to use them. The tanks are of different sizes, holding 3,856, 3,873, 4,568, and 5,000 gallons each. The heads are made of $\frac{5}{16}$-inch flange iron, the bottom of $\frac{1}{4}$-inch, and the top of $\frac{3}{16}$-inch tank iron, and they weigh about 4,500 pounds. They are about 24 feet 6 inches long and 66 inches in diameter. Those made at present hold from 4,500 to 5,000 gallons each.

Light iron tanks on wheels are used for carting the petroleum from Boyd's creek to Glasgow, Kentucky, where it reaches a railroad.

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a The barrels are first thoroughly washed, usually with a jet of steam, dried, and heated. Hot glue is then put in and distributed over the whole surface. Then by a tube a pressure of about 20 pounds per square inch is applied through the bung, and the glue is forced into the pores of the wood.—*Chem. News*, xvi, 221.

SECTION 2.—PIPE-LINES.

A wonderful revolution has taken place in the transportation of petroleum through the use of pipe-lines. The *Bradford Era* gives the following account by C. L. Wheeler:

He said in substance that the first suggestion of a pipe-line for transporting oil, so far as he knew, was made to him by General S. D. Karns at Parkersburg, West Virginia, in November, 1860. Mr. Karns said that as soon as he could raise the money he would lay a six-inch gas-pipe from Burning Springs to Parkersburg and let the oil gravitate to the Ohio river, a distance of 36 miles. For some reason this line was never laid. Some years after, Mr. Wheeler was unable to recall the exact date, a Mr. Hutchinson, inventor of the rotary pump which bears his name, conceived the idea of forcing oil through pipes, and explained his plan to John Dalzell and the narrator in the latter's office in Titusville. Subsequently Hutchinson's plans became a reality, the first pipe-line being laid from the Sherman well to the terminus of the railroad at Miller farm, a distance of about 3 miles. The inventor's idea of the hydraulic pressure of a column of that length was certainly very exalted, and he took elaborate pains to prevent the breaking of pipes. At intervals of 50 or 100 feet were air chambers like those on pumps, 10 inches in diameter, for the purpose of equalizing the pressure. These queer protuberances gave the line the appearance of a fence with ornamental posts and excited great curiosity. The weak point, however, was the jointing, which, as the pipes were of cast-iron and imperfectly finished at their ends, was very defective, and the leakage from this cause was so great that little, if any, oil ever reached the end of the line. It was a success theoretically, but a mechanical failure. Thus the expectations of easy and cheap transportation for crude oil raised by the building of the first pipe-line were ruthlessly dashed to the ground and the inventor discontinued his experiments in despair.

The first successful pipe-line was put down by Samuel Van Syckle, of Titusville, in 1865, and extended from Pithole to Miller's farm, a distance of four miles. In the fall of 1865 Henry Harley began the construction of a pipe-line from Benninghoff run to Shaffer farm, and finished it the following spring. Meantime the firm of Abbot & Harley had secured control of the Van Syckle line, and they afterward purchased enough of the Western Transportation Company's stock to control the charter and organized under it. The two lines thus consolidated were brought into successful operation under the name of the "Allegheny Transportation Company".

After the doubters were silenced by the prospect of success, the enterprise met with the most determined opposition from the army of teamsters and roustabouts, who supposed their interests were invaded by the use of pipe-lines. Mr. Harley was threatened with personal violence, his oil-tanks were burned, attempts were made to destroy the pipe-line by breaking the joints, and personal violence was offered to the men employed upon it. A few detectives, employed as teamsters, soon effected the arrest of the ringleaders, and the opposition ceased. (*a*)

At the present time the pipe-lines not only form a complete network throughout the oil regions, but there are trunk lines which extend from the oil regions to Pittsburgh, Cleveland, Buffalo, New York, and Williamsport. These trunk lines transport the oil of large areas to those cities under a high pressure, delivering thousands of barrels daily. They are laid for miles through the forest-covered hills and valleys of northern Pennsylvania and southern New York, across hills and rivers, on the surface of the ground or only slightly covered. These main lines are 6-inch pipe tested to a pressure of 2,000 pounds to the square inch and joined with couplings, into which the lengths of pipe are screwed, as are ordinary gas or water pipes.

Each well has a tank, usually of wood, holding an average of perhaps 250 barrels. With these well tanks are connected 2-inch pipes, converging toward a central point, to which there is fall enough to cause the oil to descend. Occasionally wells are so situated that the oil has to be forced by a pump over a hill.

The lines are provided with cocks and gates for opening and closing connections, and the large corporations constantly employ a corps of men in laying and taking up pipe as connections are made with new wells or broken with others. It is impossible to compute or estimate accurately the vast length of these 2-inch pipe connections. Wells are connected and left to flow for months or years, with only an occasional visit of the owner or agent. Only that proportion of the producing interest controlled by firms or corporations of strict business habits really know approximately how many miles of pipe they own, and therefore an accurate enumeration was found to be impossible; but it is safe to say that there are thousands of miles of 2-inch pipe laid for transporting oil not owned by the pipe-line companies. These lines run everywhere through the streets of towns, across fields and door-yards, under and over and beside roads, and terminate at pumping stations, at racks, or in storage-tanks. There are also racks and storage-tanks on the main lines.

The pumping stations are located at central points in the valleys. These stations consist of permanent buildings, a boiler-house and a pump-house, which contain the necessary steam-power and a steam- and oil-pump combined in one. Many of these pumps are of the Worthington pattern, and are very powerful machines, forcing the oil rapidly through great distances and in vast quantities, not only over the hills that are encountered in the course of the line, but against the friction of the pipe conveying the oil; an element in the problem of vast importance when it is remembered that the friction increases enormously as the flow of the oil is increased in rapidity. The friction on the 108 miles of 6-inch pipe between Rixford and Williamsport, Pennsylvania, is found to be equal to a column of oil 700 feet in height; that is to say, if the pipe were laid on a uniform descending grade of 700 feet between the two points and filled with oil, the friction or the adhesion between the oil and iron would prevent the oil from flowing For these reasons the pressure carried on these pumps is frequently from 1,200 to 1,500 pounds to the square inch.

a Henry's *Early and Later History of Petroleum*.

The racks are used for loading oil from pipe-lines into tank-cars, and are so arranged that any number of cars, from one to an entire train, can be loaded at the same time. They are constructed after the following general plan: The line is brought alongside the railroad track, and perpendicular branches are brought up just as far apart as the length of a tank-car. A platform is erected of a convenient height, and each perpendicular branch-pipe is provided with a stop-cock and an elbow above it. To this elbow is attached an adjustable pipe, usually of tin, long enough to reach the man-hole of the tank-car as it stands upon the track. To load a train it is run upon the track in front of the rack, the man-hole plates are all removed, the adjustable pipes placed in position to discharge the oil into the tanks, and the oil turned on. In this way as many cars as the rack will hold, perhaps 20, holding 2,000 barrels of oil, can be loaded in an hour and a half.

The storage-tanks are situated at convenient points for construction and use in filling and emptying. Standing on the hill south of Kendall, and looking north up the Tuna valley toward Limestone, I counted about 60 of these huge storage-tanks in sight. They are placed upon the ground without any foundation, the surface being carefully leveled to receive them. The following table shows the relative capacity, dimensions, and weight of the different sizes:

Capacity.	Diameter.	Height.	Weight and value.	Sizes of iron.
Barrels.	*Feet.*	*Feet.*		
37,065.66	95.4	29	90 tons; value, $9,000; 5 cents per pound.	54 plates, No. 6, sketch.
				34 plates, No. 00, rectangular.
				68 plates, No. 0, rectangular.
				34 plates, No. 3, rectangular.
				34 plates, No. 4, rectangular.
				34 plates, No. 5, rectangular.
				200 plates, No. 6, rectangular.
				34 plates, No. 7, rectangular.
31,000.00	86.0	30	80 tons; value, $8,000; 5 cents per pound.	48 plates, No. 6, sketch.
				32 plates, No. 0, rectangular.
				32 plates, No. 1, rectangular.
				32 plates, No. 2, rectangular.
				32 plates, No. 3, rectangular.
				32 plates, No. 4, rectangular.
				32 plates, No. 5, rectangular.
				165 plates, No. 6, rectangular.
26,000.00	87.0	$24\frac{8}{12}$	66 tons; value, $7,260; $5\frac{1}{2}$ cents per pound.	46 plates, No. 6, sketch.
				31 plates, No. 1, rectangular.
				31 plates, No. 2, rectangular.
				31 plates, No. 3, rectangular.
				31 plates, No. 4, rectangular.
				31 plates, No. 5, rectangular.
				169 plates, No. 6, rectangular.
22,000.00	85.0	22	53 tons; value, $5,830; $5\frac{1}{2}$ cents per pound.	54 plates, No. 7, sketch.
				26 plates, No. 2, rectangular.
				26 plates, No. 3, rectangular.
				26 plates, No. 4, rectangular.
				26 plates, No. 5, rectangular.
				26 plates, No. 6, rectangular.
				156 plates, No. 7, rectangular.
16,000.00	70.0	24	45 tons; value, $5,400; 6 cents per pound.	38 plates, No. 7, sketch.
				50 plates, No. 3, rectangular.
				25 plates, No. 4, rectangular.
				25 plates, No. 5, rectangular.
				25 plates, No. 6, rectangular.
				82 plates, No. 7, rectangular.
				25 plates, No. 8, rectangular.
10,000.00	60.0	$20\frac{8}{12}$	38 tons; value, $5,320; 7 cents per pound.	38 plates, No. 6, sketch.
				40 plates, No. 4, rectangular.
				40 plates, No. 5, rectangular.
				80 plates, No. 6, rectangular.
				20 plates, No. 7, rectangular.
5,900.00	45.0	20	15 tons; value, $2,100; 7 cents per pound.	20 plates, No. 8, sketch.
				15 plates, No. 5, rectangular.
				30 plates, No. 6, rectangular.
				15 plates, No. 7, rectangular.
				44 plates, No. 8, rectangular.

The following specifications, used by the United Lines in making contracts, will give a very good idea of their construction:

UNITED PIPE-LINES.—SPECIFICATIONS FOR 35,000-BARREL TANKS.

DIMENSIONS.—Tank to be 93 feet in diameter and 30 feet high, and be composed of 7 rings.

SHEETS.—The first ring to be of No. 00 (Birmingham gauge), weighing 13.64 pounds per square foot. The second ring to be of No. 0 (Birmingham gauge), weighing 12.04 pounds per square foot. The third ring to be of No. 1 (Birmingham gauge), weighing 11.40 pounds per square foot. The fourth ring to be of No. 2 (Birmingham gauge), weighing 10.40 pounds per square foot. The fifth ring to be of No. 3 (Birmingham gauge), weighing 9.55 pounds per square foot. The sixth ring to be of No. 4 (Birmingham gauge), weighing 8.83 pounds per square foot. The seventh ring to be of No. 6 (Birmingham gauge), weighing 8.15 pounds per square foot. The bottom to be of No. 6 (Birmingham gauge), with 5 sketch plates, weighing 8.15 pounds per square foot.

ANGLE-IRON.—The bottom angle-iron to be 4 by 4 by ½. The top angle-iron to be 2 by 2 by ⅜.

RIVETS.—The bottom angle-iron and first ring to be riveted with ⅝-inch rivets; the second and third rings with ½-inch rivets driven hot, and the remaining rings with ⅜-inch rivets driven cold. The vertical seams of the first, second, third, and fourth rings to be double-riveted.

ROOF.—The roof to be conical, with a rise of at least 5 feet 6 inches to the center (1.2 inches to the foot), and to be covered with No. 20 iron, painted on both sides, and riveted to the top angle-iron. The ends of the rafters supporting the roof must not rest on the angle-iron, but upon posts placed next to the shell of the tank inside.

MAN-HOLE.—The man-hole to be of wrought-iron throughout, and 20 inches in diameter, and be placed 10 inches from the bottom of the first ring in the sheet adjoining that in which the outlet-valve is placed.

HATCHES.—There shall be two hatches in the roof, each 2½ by 3 feet, provided with suitable covers. One of the hatches shall be directly over the outlet-valve; the position of the other to be determined by the superintendent of the United Pipe-Lines.

SWING-PIPES.—There shall be two swing-pipes, one of 6¼-inch casing, for oil, and one of 1½-inch pipe, for water; each pipe to be 30 feet long, and to have 50 feet of chain fastened to it by clamps; the chain for the 6¼-inch pipe to be $\frac{5}{16}$-inch, and the chain for the 1½-inch pipe to be ¼-inch.

FLANGES.—The flange for the pipes to be of wrought-iron, and securely riveted to the tank; the flange for the 6¼-inch pipe to be at least 1¼ inches thick where the thread is cut.

VALVES AND CONNECTIONS.—The oil-valve to be a 6-inch iron body, brass-mounted, flanged gate-valve. The connections for the oil swing-pipe to consist of one 6-inch nipple (8 threads to inch), with 10 inches of thread on one end and ordinary thread on other end. One 6-inch elbow (8 threads to inch). One 6-inch elbow (8 threads to inch) on one end, and 6¼ casing-thread on other end. One 6-inch nipple 18 inches long, ordinary threads both ends (8 threads to inch). The water-valve to be a 1½-inch iron body screwed gate-valve. The water connections to be one 1½-inch nipple, with 6 inches of thread on one end and ordinary thread on the other. One 1½ nipple 6 inches long, with ordinary thread, both ends. Two 1½-inch elbows.

WINDLASS.—There shall be a windlass over one of the hatches to raise the swing-pipes.

STAIRS.—The stairs to be substantially constructed and furnished with a gate. The tank to be carefully painted with red paint, and to be completed in every part in a thorough and workmanlike manner.

The standard tank adopted by the United Pipe-Lines is the second on the list, practically holding 30,000 barrels of oil, and over 20,000,000 barrels of oil are stored in these tanks of various sizes. (*a*) The oil is subject to depreciation in value from evaporation and by leakage through the roof of the tank, by which it is converted into an emulsion locally known as "B. S.", from which the water will not separate until the emulsion is heated. These tanks are also constantly exposed to danger of fire from lightning and other accidental causes.

SECTION 3.—CONCERNING IRON-TANK FIRES.

The following discussion of the subject of tank fires is mainly abridged from an elaborate discussion of the subject by William T. Scheide, superintendent of the United Pipe-Lines:

A few of the tanks have roofs of No. 12 iron riveted and calked, but the majority have a conical, wooden roof, covered with No. 20 iron. The plate-iron roofs are more expensive, and do not remain water-tight. Iron roofs, when sunken and covered with water, are especially bad, owing to changes in the form of the shell, due to changes in the temperature, and also to filling and emptying the tank. The roof adopted is wooden, with a pitch of 1.2 inches to the foot from the center, supported on posts set inside the tank and covered with No. 20 iron, nailed to the wood and securely riveted to the shell.

Such a tank, containing 80 tons of iron, and resting upon 5,800 square feet of earth, upon which it is pressed by more than 4,000 tons of oil, would seem to be safe from lightning. The danger comes from the liability of the gas that is continually rising from the oil to be lighted from the bolt. Mr. Scheide thinks the roofs are tight enough to prevent the escape of gas, and that the firing takes place inside; but this is scarcely possible from the manner of their construction, and it is probable that the firing is due to the ignition, either within or without the tank, of an explosive mixture of gas and air. Mr. Scheide considers that the introduction of the spark can take place by following the pipes and leaping across some air space, as the tanks and pipes of the whole region are connected in a network.

These pipes are connected with the tanks in either of two ways:

1. They run up the sides and over the top of the tank, bending into the hatchway, in which case they are held to the shell of the tank by an iron band, fastened to the roof (making a connection), and extending 12 or 15 inches through the hatch into the tank. If such a pipe were struck, and the entire bolt was not conducted to the earth through and over which it passes, the residue would leap through the mixed air and gases over the oil and

a April, 1882, 27,000,000 barrels.

fire them. To provide against this such pipes are now being bolted to a flange on the shell, and do not project through it. This arrangement is necessary for station tanks, where it is required to see the flow of oil in order to judge whether the pipe is intact.

2. As the majority of tanks are storage rather than station tanks, they are not so arranged. Oil is pumped into these through a pipe that enters through a flange at the bottom. To provide against the collection and freezing of water which settles from the oil about the outlet valve, the pipe is continued through the shell by what is called a "swing-pipe", the end of which is intended to be constantly above the surface of the oil. In this case, as in the other, the residuum of a charge might leap from the pipe to the shell and fire the tank. This swing-pipe is raised and lowered by a chain, one end of which is fastened to the pipe, and the other to a windlass placed above one of the hatches, the chain passing through the roof. Mr. Scheide suggests that such tanks be disconnected from the pipes, but remarks that the ground becomes very dry beneath them, and hence they are not in as complete connection as might at first be supposed. At the same time no such isolated tank has ever been burned. Continuing, he says:

The great majority of tanks lost by lightning have been station tanks with pipes running over the roof; but there have been tanks burned where the only pipe connection was through the shell near the bottom, the spark evidently going from the end of the swing-pipe. Well tanks of wood (usually 16 feet in diameter and 8 feet high) are quite frequently destroyed, though not more frequently in proportion to their number than iron tanks. There is always a 2-inch pipe leading over the top of these tanks and resting against the derrick over the well. This derrick, being 70 or 80 feet high, is very liable to be struck. The noteworthy point about these fires is that the pipe that leads to the tank has its other end connected with the tubing and casing in the well, and is thus afforded the most perfect earth connection conceivable. The firing in these cases is due, first, to the presence of an explosive mixture formed by the mingling of the gas from the fresh oil and the air; and, second, to the residual discharge from the end of the pipe. Either the mixture without the discharge or the discharge without the mixture would be harmless.

When a tank is fired, the roof is always blown off if there are several feet of gas space between it and the oil. There have been instances where this explosion was sufficiently intense to blow the tank to pieces. When, as has been the case this year, the tank is practically full, the explosion only starts the roof, and the fire may be, and occasionally is, extinguished by covering the rents with wet blankets, or by turning in steam. Usually, however, a tank once fairly aflame has to burn, and attention is directed exclusively to saving adjoining property. In a country as broken as this it is difficult to find sufficient ground to separate the tanks widely without going to unwarranted expense, so that from 200 to 300 feet is considered a fair interval between them. Very many are much closer than this.

A tank once fairly on fire will burn from 6 to 8 inches an hour, and will not endanger neighboring tanks (unless high wind carries the flames over them) for several hours. The danger comes usually from the "overflow"—the most extraordinary phenomenon attending an oil fire. After a period varying, in a full tank, from 5 to 12 hours, or even a little more, and when the oil has burned down about 5 feet, the tank suddenly and without any previous notice throws out in a grand flow from 8 to 12 feet (8,000 to 12,000 barrels) of burning oil. To prepare for this flood all our energies are directed until it comes. Ditches are dug and embankments thrown up between the burning tank and other property, and, if possible, the ditches are made to open into fields, where the oil can burn rapidly and without further damage.

The oil burns on the ground or on water with incredible rapidity, and will not run very far from the tank. When the flow ceases, it loses its limpidity, as its lighter parts are consumed, and when carried forward by water the flames die out in a comparatively short distance, leaving the surface covered with thick, dark-green, unconsumed oil.

At certain intervals after the first flow there will be smaller flows, and in from twenty-four to thirty-six hours the tank will be quite burned out.

The cause of these overflows is uncertain. They are probably owing, in part at least, to the heating of the subjacent oil, but not wholly.

At the Custer fire our superintendent went completely around within five minutes of the flow, and as far as he could reach the tank was quite cool to the hand.

The theories offered to account for the overflow are chiefly, first, heating the sides of the tank causes the oil to boil; second, currents of air caused by the fire itself; and, third, that, as the more volatile parts of the oil burn first, the burning surface will, after a time, become thick enough to seriously impede the free flow of gas from the oil beneath, and this obstruction becomes sufficient to permit or cause the accumulation of a quantity of gas so considerable as when it is suddenly relieved to cause the overflow. It is certain that the force excited is very great. At Custer the flow was made with such vehemence as to extinguish the flames in the tank, and for several minutes the oil left in the tank was not burning, only catching again from the fire outside.

To shorten the time during which the tank burns we "shoot" it with small cannon or rifles. Through the holes thus made a considerable quantity of oil escapes, and though the area and intensity of the fire is increased the time of danger is lessened. When spouting from holes made by rifle-balls the oil burns with an exceedingly brilliant, pure white flame, almost comparable to the electric light. Another object in shooting is to lessen the overflow by reducing the volume of unburned oil in the tank. The flames of a burning tank take a whirling motion, tending toward the center of the tank; when there is no wind the column of flame and smoke covers about two-thirds of the surface of the tank, the strong rotary movement drawing the flames from the circumference. The combustion is naturally very imperfect, and the column is chiefly dense black smoke, through which the flames, in great brilliant jets of fire, burst continually.

In a private communication of later date Mr. Scheide says:

1. We think lightning-rods are an advantage; we rodded nearly all the tanks last summer, and the result (if it was the result) indicates the advantage. Seven tanks were fired; three had no rods, and four had. But one of the four was a station tank undergoing repairs to the roof, and we think the evidence is that the discharge came from the pipe. As at least 90 per cent. of the tanks were rodded, the showing of last summer we think favorable. The rod is an inch-round iron rod 25 feet long, screwed into two iron bands (4 inches by ½ inch), which cross each other at the apex of the roof and run radially to the circumference, where they are carefully riveted to the top angle-iron, and so to the shell. The idea is that the shell may help discharge itself as far as possible above the roof, and the spark thus kept out of the vicinity of the escaping gas. The bands are further fastened to the roofing iron (previously scraped and cleared) by screws.

2. All recent tanks have been built without swing-pipes. An arrangement devised by one of our men keeps the water out of the gate-valve, through which the tank is filled and emptied. We are now lowering the swing-pipes in all other tanks on the bottom of the tank, there to remain until fall. I think this is quite important.

3. The ground (electrical) connections of the tanks we find on test to be very much better than expected. We have had every tank in the field tested for its electrical connection with the earth and with the rods. Owing to the extreme difficulty in obtaining a perfect "ground" to test to, our results are only approximate, but a vast majority of the tanks show an average earth resistance of not exceeding 6 ohms. Their true resistance is probably much less. We were unable to get any resistance in the rod connections. We were prepared with no less resistance coil than one-hundredth of an ohm, and none of the rod connections gave as much resistance as that coil.

4. We have increased the distance between the tanks: 350 feet from shell to shell is now the minimum distance, and the average is 400 feet.

5. We are confident we can prevent the overflow if we can draw the oil out of the burning tank fast enough. A 3½-inch cannon seems about the best instrument for the purpose, but we are experimenting with a machine that seems to promise well, which will cut a 6-inch hole without any jar to the tank, and be operated by power from a safe distance. About a dozen 3½-inch shots will empty a tank fast enough to prevent an overflow.

6. We have given a great deal of thought to the matter of extinguishing fires. We conclude thus far that this can only be done while the roof is yet comparatively whole (it is often several hours before the roof disappears), and by steam or carbonic acid. We think steam the surest, as it can be generated more steadily. We have a large "gas-engine", with a capacity of 2,000 cubic feet per charge, but experimental tests have not encouraged us. We tried it also at an actual fire, but it was not in first-class order, having been partly broken in transit. We have built a number of 30-horse boilers and fitted them for rapid steaming with oil fuel, which we think will prove effective. We expect to have at least two of these boilers at a burning tank, with steam on, in an hour and a half at most from when it was struck, having organized very thoroughly a fire department at each of our tankage points completely supplied with every tool and machine necessary at an oil fire.

The burning of a large oil-tank at night is described as one of the grandest spectacles that can be witnessed. Considering the fact that whenever a thunder-storm passes over the oil regions it is quite probable that one or more tanks will burn, and also the seeming recklessness with which these vast reservoirs of combustible material are located in and near large towns, escape from terrible disaster seems providential. There have been several serious warnings. Red Rock station, on the Olean and Bradford narrow-gauge railroad, was burned in November, 1879. A wooden 250-barrel tank having taken fire from a lantern, the oil from this small tank ran down the valley and struck a large iron one. The flames being as high as the tank, soon set its contents on fire. The tank of oil began to burn about 7 p. m., and continued to burn quietly until 4 a. m., when it overflowed. The burning oil streamed over the sides, and, running down the main street, set the town on fire. The tank fire at Summit City was witnessed by a large company on the hill above, who were waiting for the overflow. A man fired into it with a Winchester rifle, around the circumference and at about the same height from the ground, making a fountain of fire as the jets ignited successively. Finally the oil poured over the sides all around, and a column of flame ascended at least 300 feet in height, and spread out in a horizontal sheet, like an umbrella. A gentleman beneath this sheet of flame and several hundred feet from the tank had his hat scorched.

Hair-breadth escapes from destruction are often recorded. A tank near Tarport was fired by lightning in the summer of 1880. The explosion split the cover across from side to side and set the oil on fire, the flames streaming out of the man-hole in the cover. Wet blankets were placed over the hole at first without success, but finally, by doubling them and putting wet carpets along the crack in the cover, the flames were smothered and the tank saved. On another occasion a 250-barrel wooden well tank, 16 feet in diameter and 8 feet high, nearly full of oil, and covered with loose boards, was fired by a thunderbolt. A workman near by wet his coat and thrashed out the flames. His employer gave him $50, but told him not to risk his life another time for so small a value. These may be taken as examples of hundreds of similar incidents.

It may not be out of place here to remark that very disastrous fires have sometimes resulted from the ignition of gas at the well head when the oil-rock is perforated. One of the most disastrous fires of this kind on record occurred in 1861 on the John Buchanan farm, on the east side of Oil creek. The well was at the mouth of a small ravine formed by the waters of a spring, which, spreading out, had formed a small marsh. The well had first been drilled to the first sand and afterward put down deeper, and must have poured forth a stream of 3,000 barrels a day, as the marsh was immediately flooded with oil. The catastrophe is thus described by an eye-witness:

Just after supper on the evening of April 17, 1861, Mr. H. R. Rouse, Mr. Perry, Mr. Buel, myself, and others were in the sitting-room of Anthony's hotel, when a laborer on the fatal well hurried into the room to say that a monstrous vein of oil had been struck and barrels were wanted to preserve it. All ran to the well with the exception of myself, and I, not seeing the man who attended to the distribution of barrels, started in the opposite direction for teams to haul the necessary packages. I had completed my errand, and was on a full run for the well, with less than 20 rods to make, when an explosion occurred which nearly took me from my feet. On the instant an acre of ground, with two wells and their tankage, a barn, and a large number of barrels of oil were in flames, and from the circumference of this circle of fire could be seen the unfortunate lookers-on of a moment before rushing out enveloped in a sheet of flame that extended far above their heads, and which was fed by the oil thrown upon their clothing by the explosion. * * * The well burned three days before it could be extinguished, which was finally done by smothering it with manure and earth. Its appearance while burning was grand. From the driving-pipe, 6 inches in diameter, to the height of 60 or 70 feet arose a solid column of oil and gas, burning brilliantly. Above this hovered an immense cloud of black smoke, which would seize sections of the ascending flames, and rolling over and over, first exposing to the view cloud and then flame, would rise a hundred feet higher before the flame would fade out. From the main column below millions of individual drops of oil would shoot off at an angle, and then turning the arc of a circle drop burning to the ground, presenting all the hues of the rainbow, making a scene like enchantment, the whole accompanied by a roar hardly inferior to that made by Niagara Falls. (*a*)

Mr. Henry R. Rouse, one of the owners of this well, was among those fatally burned. On other occasions a fountain of oil projected high into the air has burned continually for weeks before the flames could be smothered.

a Henry's *Early and Later History of Petroleum*, p. 338.

Oil in transit in tank-cars has also occasioned terrific fires. Travel stopped ten hours on the Central railroad of New Jersey in 1876 by the burning of oil cars. The following telegraphic dispatch illustrates the extent of such disasters:

PORT JERVIS, NEW YORK, *October* 5—3 p. m.—The fire broke out at 1.40 p. m., and is burning fiercely. There are fifteen cars in the train, which are exploding one after the other. No one dares approach within a hundred feet of the train. Rails will have to be laid for a distance of nineteen car-lengths before trains can pass.

The following is from *Stowell's Petroleum Recorder*, June, 1880:

The greatest oil fire on record occurred in Titusville, Pennsylvania, on the 11th of June, 1880. It continued three days, and was caused by lightning striking a large iron tank filled with crude oil on a hill south of the city, from which the burning fluid rolled down the declivity, consuming refineries, tanks of crude oil, tanks of benzine, tanks of distillate, houses, stables, and bridges; burning some 200,000 barrels of oil, 8 or 10 iron tanks, 2 refineries, 2 bridges, 20 or 30 dwellings, and everything that could be burned in its resistless course to the creek below. The estimated loss was $500,000.

The United Pipe-Lines mutually insure their patrons against losses by fire and other accidents. The following notice will illustrate the manner in which the assessments are made after any accident which involves a loss of oil:

GENERAL OFFICE UNITED PIPE-LINES,
Oil City, Pennsylvania, August 30, 1880.

The patrons of the United Pipe-Lines are hereby notified that all credit balances upon the books of the United Pipe-Lines at the close of business August 28, and all outstanding acceptances issued on and before that date, are subject to an assessment of twenty-one one-hundredths ($\frac{21}{100}$) of 1 per cent. in pipeage paid oil, on account of loss by fire, on August 28, 1880, of tank United register No. 738, located at Babcock, on the Erie railroad, McKean county, Pennsylvania.

WILLIAM T. SCHEIDE, *General Manager.*

SECTION 4.—CONCERNING THE STORAGE OF OIL AND ACCUMULATED STOCK.

The legislature of Pennsylvania has required the incorporated pipe-lines whose certificates are negotiable paper to publish a monthly statement of their condition. The following abstract of a report made in conformity to the requirements of that law affords a sufficient illustration of its operation:

STATEMENT OF THE TIDE-WATER PIPE COMPANY, LIMITED.

(Made in compliance with the act of assembly approved May 22, 1878.)

First. Quantity of crude petroleum which was in the actual and immediate custody of said company at the beginning of the month of March, 1881, 1,594,900.68 barrels.

Quantity of crude petroleum which was in the actual and immediate custody of said company at the close of the month of March, 1881, showing where the same was located or held, describing in detail the location and designation of each tank or place of deposit, and the name of its owner, viz:

Designation of tank.			Name of owner.	Location.	Barrels and hundredths of barrels of 42 gallons each.
Wood or iron.	Marked.	Numbered.			
Iron	Tide-Water Pipe Company, limited	2	Tide-Water Pipe Company, limited	Otto township, McKean county, Pennsylvania	25, 238. 86
Iron	do	12	Knapp's Creek Oil Company, limited	do	23, 803. 26
Iron	do	15	Hoyt & Emerson *et al*	do	25, 608. 53
*	* *	(*)	* *	* * *	1,459,695.10
Wood		1	do	Gibson's Point, Philadelphia, Pennsylvania	438. 29
Iron	Tide-Water Pipe Company, limited	63	do	do	3, 110. 68
Iron	do	66	do	Thurlow, Delaware county, Pennsylvania	29, 884. 66
Iron	do	67	do	do	28, 114. 48
				Total fluid in tanks	1, 595, 902. 86
				Less sediment and surplus	33, 903. 97
				Net amount of oil in tanks	1, 561, 998. 89
Contained in 138 tank-cars in transit. Capacity, 106.66 barrels each				Between Williamsport, Pennsylvania, and Bayonne, New Jersey.	14, 719. 08
Contained in 28 tank-cars in transit. Capacity, 106.66 barrels each				Between Williamsport and Philadelphia, Pennsylvania.	2, 986. 48
Contained in 41 tank-cars in transit. Capacity, 106.66 barrels each				Between Philadelphia and Thurlow, Pennsylvania.	4, 373. 06

Miles of pipe.	Inside diameter.	Capacity per mile.	Total capacity.	Estimated contents.
	Inches.	*Barrels.*	*Barrels.*	*Barrels.*
93. 95	2. 067	21. 914	2, 058. 82	1, 029. 41
27. 68	3. 067	48. 247	1, 335. 48	1, 335. 48
14. 93	4. 026	83. 137	1, 241. 24	1, 241. 24
108. 24	6. 065	188. 672	20, 421. 86	18, 379. 67
2. 04	7. 982	326. 790	666. 65	666. 65
0. 62	12. 025	741. 677	459. 84	459. 84

Total	23, 112. 29
Total barrels	1, 607, 180. 80

Second. Quantity of crude petroleum which was received by said company during the month of March, 1881, 159,874.51 barrels.

Third. Quantity of crude petroleum which was delivered by said company during the month of March, 1881, 145,699.68 barrels.

Fourth. Quantity of crude petroleum for the delivery or custody of which said company was liable to other corporations, companies, associations, or persons at the close of the month of March, 1881, 1,607,189.80 barrels.

Fifth. Amount of such liability which was represented by outstanding certificates, accepted orders, or other vouchers, 1,325,400 barrels.

Amount of such liability which was represented by credit balances, 281,789.80 barrels.

Sixth. All the provisions of the act above referred to have been faithfully observed and obeyed during the said month of March, 1881.

No refined petroleum was in the custody of said company during the month of March, 1881, nor was said company liable during the month for the delivery of any refined petroleum.

D. B. STEWART.
B. F. WARREN.

COMMONWEALTH OF PENNSYLVANIA,
County of Crawford:

Before me, a notary public within and for said county, duly authorized by law to administer oaths, personally came D. B. Stewart, having charge of the books and accounts of the Tide-Water Pipe Company, limited, and B. F. Warren, having charge of the pipes and tanks of said company, who, being each duly sworn, depose and say that they are familiar and acquainted with the business and condition of said company and with the facts set forth in the above report, and that the statements made therein are true to the best of their knowledge, information, and belief.

Subscribed and sworn before me this 9th day of April, 1881.

JOHN O'NEILL, *Notary Public.*

At the close of the census year the accumulation of gross stocks in the tanks of the United lines, according to their published statement, was 10,306,078.79 barrels, and of this 454,193.73 barrels was estimated to be "sediment and surplus". At the same time the tide-water pipe-line report gross stocks in tanks at 978,183.30 barrels and 18,657 barrels "water and sediment". Concerning this surplus Mr. Scheide writes:

Our "surplus" is the amount in which our gross stocks exceed our liabilities of all kinds, and we estimate that it is large enough to enable us to deliver all the oil we owe with a safe limit. We keep it at from 3½ to 4 per cent. of our liabilities by monthly purchases. Every year we make a careful inspection of the contents of our tanks. By an instrument called a "thief" we can take samples from any depth in the tank through four gauge-hatches in the roof. These samples, when not clearly merchantable oil, are carefully heated in white-glass bottles having leveled bottoms. The heat completely separates the oil from the water, dirt, and paraffine, which last settles in time into a compact mass at the bottom. There being a clear line of separation, the percentage of oil in the sample is thus readily obtained. In our calculations of the value of our "B. S." we usually make a further reduction of from 10 to 50 per cent. to cover the expense of the separation. This can only be determined by experts. In addition to the annual inspection, there are two experts engaged every day in inspecting the tanks to see whether the water or "B. S." is accumulating, which is about the only way we have of finding small leaks in the roof. It is impossible to give any idea as to how fast "B. S." is formed. The quantity formed differs in the widest manner in adjacent tanks; with rain carefully excluded, its formation, after that naturally in the oil (there is a small percentage in almost all fresh oil) had settled, would be commercially insignificant. We have enormously reduced its formation by the careful attention we have for two years been giving our tank roofs. I think that 3 per cent. is an ample surplus on a stock exceeding 20,000,000 barrels, but the percentage would have to increase rapidly if the stock was materially reduced.

The total net stock in tanks June 1, 1880, was estimated to be 11,737,890 barrels, exclusive of the Franklin pipe-line, the Smith's Ferry Transportation Company, and the West Virginia Transportation Company, all of which handle oils that do not enter the general trade, and also exclusive of the oil in well tanks throughout the Pennsylvania region. The condition in which much of this vast quantity of oil actually is can only be determined when it is drawn out of the tanks, in which some of it has been stored for years, although the larger portion of it is not allowed to remain more than two or three years without being changed. Oil soon loses the more volatile portion by evaporation, and increases in density, becoming more difficult to refine, but in other respects remains unchanged in quality. "Formerly, when stills were run slowly, and the product desired was the greatest possible percentage of illuminating oil, age was an advantage, and for many years oil of 45° gravity and under was worth one-half cent a gallon more than lighter oil; indeed, by a rule of the New York produce exchange, no oil of over 47° was merchantable except at a cut. For several years the greatly increased value of the other products of distillation has completely changed this rule." The oils in the tanks are therefore kept as new as possible.

William T. Scheide, in a private communication, says:

Oil is steamed in winter to free it from snow and ice and in cases to make it more limpid, as oil from very "gassy" territory thickens rapidly in the cold and will not run through any long line without warming. Orders are that the oil shall not be heated above 80° or 90° F., and not run warmer than 65° to 70°; but these figures are, no doubt, frequently exceeded. There is a great loss in this steaming, both to the producer because of the evaporation and to the pipe-line because of the condensed steam held in the oil. Many merely blow steam in and do not usually heat with a coil, as they should. The United Lines deduct from the amount shown by the gauge one-tenth of 1 per cent. for each degree F. that the temperature of the oil run stands above the temperature of the oil in three iron tanks at either Tarport or Oil City (according as the run is made in the upper or lower country), which are held untouched for this purpose.

B. F. Warren, of the Tide-Water Pipe Company, has made a very careful study of the effects of steaming oil, and has reached some conclusions, which are embraced in the following communication:

Inclosed find a tabulated statement of some results which I obtained in experiments in the field with steamed oil. You will notice some wide variations and apparent discordance in the results. These are mainly due to the imperfections of the tanks. You will understand that the tanks are of wood, and the action of steam is apt to make them leak, so much so that we almost invariably are obliged to "drive hoops" on tanks at the end of the steaming season. Some careful laboratory work gave me a rate of increase for each degree of heat from 40° to 80° F. at 0.000465; below 40° the rate of increase or decrease was noticeably less, although not measurably so, with the facilities which I was possessed; above 80° the rate seems to increase rapidly.

COMPARATIVE RESULTS OF STEAMING OIL, FROM TESTS MADE IN THE BRADFORD OIL-FIELD.

Number of tank.	Owner.	District.	COLD. Temperature.	COLD. Gauge.			STEAMED. Temperature.	STEAMED. Gauge.			Increase of temperature.	Increase of volume in barrels.	Water and B. S.	Net increase.	Rate of increase for each degree.
			Deg. F.	Ft.	In.	Barrels.	Deg. F.	Ft.	In.	Barrels.	Deg. F.				Deg. F.
292	....	Bradford	30.7	6	11⅝	235.52	77.0	7	4⅝	248.91	46.3	13.30	9.62	1.64	0.00020
811	W. Chambers	West Branch	37.8	6	11⅝	229.59	103.8	7	1	234.41	66.0	4.82	9.41	4.82	0.00036
30	—— Robbins	Dallas	26.0	6	11	223.58	86.0	7	4	235.91	60.0	12.33	1.25	10.08	0.00072
48	Ford & Weaver	...do	31.0	5	6	181.58	80.0	5	9½	190.66	49.0	9.08	......	......	......
380	Knapps Creek Comp'y.	Rixford	28.0	7	2	236.92	85.0	7	6	246.90	57.0	9.98	9.26	0.72	0.00006
459	Larmouth	Dallas	26.0	7	1	229.72	100.0	7	7	245.70	74.0	15.98	2.50	12.52	0.00074
677	D. A. Wray	Coleville	40.0	14	6¼	761.36	63.0	14	10¾	778.13	23.0	16.77	10.51	......	......
703	Evans & Houtz	...do	33.0	4	10½	169.91	94.0	5	1	176.89	61.0	6.98	......	......	......
740	Evans & Thompson	Bordell	34.0	10	7	549.59	84.0	11	0½	571.38	50.0	21.70	5.94	15.85	0.00058
838	...do	...do	30.0	10	8½	537.34	90.0	11	4	565.10	60.0	27.76	11.95	18.71	0.00055
969	Union Oil Company	...do	32.0	6	7¾	214.80	82.0	6	11½	224.11	50.0	9.31	5.58	3.73	0.00035
970	...do	...do	40.0	6	9¼	216.03	85.0	7	0¼	223.22	45.0	7.19	......	......	0.00074
1025	...do	...do	32.0	5	11	199.76	85.0	6	3	210.22	53.0	10.46	4.57	5.90	0.00056
1027	...do	...do	40.0	6	8¾	209.97	90.0	7	0¼	218.29	50.0	8.32	2.38	5.94	0.00060
1059	...do	...do	40.0	6	9¾	243.62	85.0	7	0	250.32	45.0	6.70	......	......	0.00061
1060	...do	...do	28.0	7	4¼	263.12	85.0	7	9	277.71	57.0	14.59	2.87	11.72	0.00078
1064	...do	...do	30.0	7	0½	252.66	100.0	7	7	271.96	70.0	19.30	0.75	18.55	0.00106
1065	...do	...do	34.0	7	1½	255.77	88.0	7	8¾	262.50	54.0	6.73	4.48	2.25	0.00020
1074	...do	...do	34.0	7	3½	259.88	80.0	7	6¾	269.44	46.0	9.56	0.68	8.88	0.00074
1075	...do	...do	40.0	6	3	222.75	85.0	6	6	231.66	45.0	8.91	1.49	7.42	0.00074
1076	...do	...do	42.0	6	3	223.23	90.0	6	6¾	234.37	48.0	11.14	3.71	7.43	0.00064
1076	...do	...do	40.0	7	3½	260.36	92.0	7	7½	271.27	52.0	10.91	0.70	10.21	0.00075
	Average	......	......	......	......	......	......	......	......	......	......	......	......	......	0.00058

Number of tank.	Owner.	District.	COOLING. Temperature.	COOLING. Gauge.			Temperature.	Decrease of volume in barrels.	Rate of decrease for each degree.	Gauge when run.		Remarks.
			Deg. F.	Ft.	In.	Barrels.	Deg. F.		Deg. F.	Ft.	In.	
292	....	Bradford	43.0	7	2	241.88	34.0	7.03	0.00085	7	2	
811	W. Chambers	West Branch	90.7	6	11⅝	230.08	13.0	4.33	0.00150	7	1	The small increase and large decrease of these tanks would seem to indicate a leak in tank.
30	—— Robbins	Dallas	68.0	6	11½	224.83	18.0	11.08	0.00273	6	11	
48	Ford & Weaver	...do	66.0	5	8½	188.07	14.0	2.59	0.00096	5	8½	Water not drawn.
380	Knapps Creek Comp'y.	Rixford	70.0	7	1	234.41	12.5	2.51	0.00085	6	9¼	Contained an excessive amount of water.
459	Larmouth	Dallas	68.0	7	5	239.72	32.0	5.98	0.00078	7	4	
677	D. A. Wray	Coleville	60.0	14	10½	776.28	3.0	1.85	0.00081	14	5	
703	Evans & Houtz	...do	70.0	5	0	174.10	24.0	2.79	0.00066	5	0	Water not drawn.
740	Evans & Thompson	Bordell	70.0	10	11	565.45	14.0	5.93	0.00075	10	9½	
838	...do	...do	71.0	11	2	557.84	19.0	7.26	0.00070	10	11	
969	Union Oil Company	...do	62.0	6	10½	221.63	20.0	2.48	0.00056	6	8½	
970	...do	...do	65.0	6	11½	221.43	20.0	1.79	0.00042	6	11½	Water not drawn.
1025	...do	...do	67.0	6	2	207.61	18.0	2.61	0.00070	6	0¼	
1027	...do	...do	68.0	6	11	215.32	22.0	2.97	0.00060	6	10	
1059	...do	...do	60.0	6	11½	248.09	25.0	2.23	0.00040	6	11½	Water not drawn.
1060	...do	...do	58.0	7	7½	272.69	27.0	5.02	0.00067	7	6¼	
1064	...do	...do	72.0	7	5½	267.61	28.0	4.35	0.00060	7	5½	Water not drawn.
1065	...do	...do	54.0	7	0½	251.28	34.0	11.22	0.00130	6	10½	Tank probably leaked some.
1074	...do	...do	60.0	7	5¾	266.50	20.0	2.94	0.00060	7	5¾	Water not drawn.
1075	...do	...do	64.0	6	4½	227.21	21.0	4.45	0.00090	6	4	
1076	...do	...do	66.0	6	5½	230.60	24.0	3.71	0.00066	6	4½	
1076	...do	...do	78.0	7	6¼	268.48	14.0	2.79	0.00060	7	6	
	Average	......	......	......	......	......	......	......	0.00085	......	......	

NOTE.—The quality of the oil does not appear to be affected by steaming. Except in two cases the gravity was not sensibly changed; in one case the gravity was increased from 43 to 40°, in the other decreased from 40 to 42.5° Baumé. The variation between the apparent increase and decrease is due to the fact that all oil at temperatures below 40° F. contains varying proportions of water when it comes from the wells, and will not settle until the temperature is raised. There is also a portion of the oil destroyed by the action of steam, forming so-called B. S.

The problems in hydraulics presented in the construction and management of pipe-lines, particularly those lines that may be denominated trunk lines out of the oil regions, are many and intricate, and required great courage on the part of those who projected the first line to meet and surmount them. These men had only the quite different problems and experience met in laying pipes for water to guide them. These problems dealt with a homogeneous fluid, flowing through pipes, laid permanently on curves of large diameter, flowing slowly under a low pressure and delivered slowly. This water pressure seldom exceeded from 40 to 50 pounds per square inch. The pipe-line problems dealt with a fluid varying in density with the temperature, flowing easily in summer and with difficulty in winter through pipes of small diameter, laid hurriedly and frequently changed, often on sharp curves or at right angles, for rapid movement and delivery, and at high pressures to compensate in part for the friction due to long distances and rapid transmission and small diameter of pipe, as well as at much greater elevations than are found in water-mains. The pipes used in pipe-lines are all tested to 2,000 pounds per square inch. The small sizes, 2-inch, 3-inch, and 4-inch, are worked under a pressure of 1,600 pounds, and the 5-inch and 6-inch at 1,000 pounds per square inch.

Elaborate governmental and other experiments have been made in Europe with reference to the storage and transportation of petroleum and its products. These have been mainly directed toward storing the oil under water, either in barrels or submerged cisterns, or toward a method of solidifying the petroleum or its products. The most successful plan for storing oil in submerged cisterns appears to be that of Ckiandi, an engineer of Marseilles, and consists of a cistern of masonry, provided with an inverted bell resembling a gasometer, beneath which the oil is held over water. (*a*) At Saint Ouen, near Paris, floating reservoirs of iron of an approximate capacity of 100 barrels have been used for a long time. Fourteen of these reservoirs were constructed in 1877, with a total capacity of 900,000 gallons. They were made of $\frac{3}{16}$- to $\frac{1}{4}$-inch iron, and weighed in the aggregate 151 tons. (*b*)

The so-called process for solidifying petroleum has been very widely noticed. It consists in producing with the petroleum a little water and saponaria root, an emulsion which is considered harmless for transportation. To recover the oil a little pure carbolic acid or strong acetic acid is added, and the constituents again separate. As *saponaria* is a product of the Levant and a drug of considerable value, this and other similar methods are rendered too expensive if their inconvenience was not an insurmountable obstacle to their employment. Such experiments furnish curious but impracticable results.

Concerning the proposed transportation of oil in bulk, the following from the *Oil and Drug News* presents the latest aspect of the question:

The report from Philadelphia that the steamer Vaderland, of the Red Star line, had been purchased by a number of capitalists for the purpose of transporting petroleum in bulk has attracted considerable attention at the various commercial exchanges. The transportation of oil in bulk is not entirely an experiment. A number of sailing vessels have already been fitted up for this purpose, and have, to a certain extent, demonstrated the practicability of the idea. This is the first time, however, that a steamer has been constructed solely with the view of transporting safely large quantities of petroleum in bulk. The advantages of the system are, first, that it enables a steamer to carry a much greater amount of petroleum than it could if stored in barrels; and, second, it saves the expense of the barrels, each one of which costs exactly as much as the refined oil it contains. Not only this, but it also saves the expense of returning the barrels from Europe for use again.

Inquiry among petroleum men and shipping merchants in this city elicited the general opinion that the idea is not considered practicable. Said one well-known oil inspector: "It is my opinion that the system will not work. It has been tried three times on sailing vessels during the past eight years, and each time the vessel was lost. The captain of one of them, who was saved from the wreck of his vessel, said to me that the difficulty was that the oil seemed to move quicker than water, and in rough weather, when the vessel was pitched forward, the oil would rush down and force the vessel into the waves much the same as improperly stored bulk grain does sometimes in stormy weather. It may be that by stowing the oil in small compartments it could be transported with safety, but I doubt it. Besides, what is the advantage of the system any way? The vessel must return in ballast, and it might as well bring back barrels, which under the present system are used over and over again, but under the proposed method would not be needed in the export trade."

Messrs. Slocovich & Co., the well-known shipping merchants, state that about eight years ago one of their vessels was fitted up with tanks for transporting oil in bulk. She proceeded on her journey and was never heard from. Her loss was undoubtedly due to her mode of carrying petroleum. Another shipping merchant stated that he believed the idea to be impracticable. It might be possible to make the tanks strong enough to prevent the escape of the vapor of the oil, but all previous experiments had proven failures, and there was no reason to suppose that this would succeed. An experiment to transport molasses in bulk has been tried within two or three years, and two vessels were fitted up for the purpose to run between Cuba and Boston. The experiment, however, proved a failure, and the project had been abandoned. The Vaderland is an iron screw steamship, built at Yarrow-on-Tyne, in England, in 1872, and was extensively repaired last year. Her capacity for cargo is 2,001 tons. She is owned in Antwerp.

The "oil in bulk" movement does not meet with favor among practical exporters. They say that it cannot be carried out successfully. It would seem, however, that oil might be transported in vessels in that way as well as grain, and the day will no doubt come when a means to that end will be devised.

SECTION 5.—STATISTICS OF THE TRANSPORTATION OF OIL DURING THE CENSUS YEAR.

Statistics have been received from the following-named pipe-lines that were engaged in business during the whole of the census year:

United Pipe Lines.
Tide-Water Pipe Company, limited.
West Virginia Transportation Company.
Franklin Pipe Line.
Smith's Ferry Transportation Company.
Octave Oil Company Pipe Line.

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a *Engineering*, xv, 279. *b* *London Inst. Civ. Engineers*, 1, 200. *Nouv. Ann. de la Construction* (3), ii, 83.

Fox Farm Pipe Line.
Shæffer and Charley Runs Pipe Line.
Tidioute and Titusville Pipe Line.
T. C. Joy.

There were also four other pipe-line companies doing business at the beginning of the census year that went out of business during that year, of which such statistics are incorporated with those of the other lines as can be obtained from their printed statements. These lines are:

Pennsylvania Transportation Company.
Church Run Pipe Line.
Cherry Tree Run Pipe Line.
Emlenton Pipe Line.

Beside these lines, there were a number of small private lines, particularly in the lower country, of which no reports are published, and from which it was impossible to obtain statistics, except at an unwarranted expenditure of time and labor, if, indeed, they could be obtained at all. These statistics, if obtained, would not materially change the significance of the figures here presented.

The total amount of capital invested in the ten pipe-lines above mentioned was $6,347,930, and the total amount paid in wages during the year was $769,641. The greatest number of hands employed by them during the census year was 1,381; the average number 1,107, of whom 1,098 were males above sixteen years, 6 were females above fifteen years, and 3 were children.

The hours of labor constituting a day were in general ten, but some of the operations of pipe-lines require constant oversight, and therefore in some instances the labor is performed by men who work in "tours" of twelve hours each, extending from twelve o'clock at midday to twelve o'clock at night, and from twelve o'clock at night to twelve o'clock at midday.

The ten lines in operation at the end of the year were in operation throughout the year.

The average wages of skilled workmen varied from $1.75 to $3.33 per day and from $70 to $75 per month; that of ordinary laborers from $1.25 to $2.50 per day.

A marked difference in the rate of wages is found to exist in different sections of the oil-producing country. This difference is no doubt determined to some extent by the magnitude of the operations of the lines and the responsibility attaching to the labor performed.

The total amount expended for fuel by these ten lines (not including the value of a vast quantity of natural gas, of which no account was taken) was $127,058. The total amount received for transporting (piping) oil was $1,381,328. The total number of boilers used was 216, having an estimated horse-power of 4,301; of pumps on main lines, with a diameter of cylinder varying from 3 to 34½ inches, and a length of stroke varying from 4 to 36 inches, 383; of pumps used in collecting oil (for the most part small portable pumps), 511; of iron tanks, 646, with a total capacity of 12,958,385 barrels; and of wooden tanks, 383, with a total capacity of 239,587 barrels.

The total miles of pipe controlled by pipe-lines was:

	Miles.
12-inch pipe, several hundred feet.	
6-inch pipe	121.66
5-inch pipe	7.75
4-inch pipe	123.73
3-inch pipe	289.65
2½-inch pipe	16.00
2-inch pipe	1,716.23
1½-inch pipe	2.78
1-inch pipe	9.05
Total miles of pipe	2,286.85

	Barrels.
The stock of oil on hand in tanks and pipes June 1, 1879, was	6,753,909.02
In the other four lines	28,795.33
Total	6,782,704.35
The amount run into these lines during the census year was	22,516,676.27
Into the other four lines	370,110.96
Total	22,886,787.23
The stock on hand in tanks and pipes May 31, 1880, was	11,239,555.73
In the other four lines	18,022.31
	11,257,578.04
The amount transported through the pipes during the year was	18,411,913.54

There were 36 racks belonging to these lines, at which 561 tank-cars could be loaded at one time, and 287 tanks on cars, having an aggregate capacity of 30,230 barrels.

CHAPTER IX.—PETROLEUM IN COMMERCE.

SECTION 1.—COMMERCIAL VARIETIES.

Few persons are aware that there is more than one variety of petroleum, and those who know that some petroleums are relatively heavy and are used for lubrication suppose the light oils to be of one definite quality. The petroleum of Oil creek in early days was known to be inferior for many purposes to the amber oil of the lower Allegheny. During the first ten years of its development the oil produced in Pennsylvania was practically one thing, and the light oils of West Virginia and southern Ohio were not particularly different. The wonderful expansion of the lower Allegheny field, which commenced in 1872, was accompanied by a corresponding decline in the Oil Creek district in such a manner that the bulk of the production was shifted from the green oil of Oil creek to the amber oil of Armstrong and Butler counties. It was soon discovered that this amber oil was of superior quality for refining purposes, so superior, in fact, that refiners would secure it if possible. When, in 1876, the production of the Bradford district assumed importance, it was discovered that it was the least valuable variety of petroleum for refining yet discovered in large quantities. The price of oil from these different sections has, however, been uniformly the same, irrespective of quality, and has been the ruling price in commerce.

At the same time the heavy oil of Mecca has been sold at from ten to twenty times the price obtained for the light oils of other districts. Those of Belden, Ohio, and West Virginia have been graded according to their density and the effects of cold upon them. The Smith's Ferry oils have been sold for about three times the value of the light oils, and the Franklin oil at five to six times the value of the same.

The West Virginia Transportation Company divides the oil which it handles, which embraces the larger portion of the production of West Virginia and a part of that of Washington county, Ohio, into seven grades, as follows:

A, 37.1° Baumé and lighter.
B, 33° to 37° Baumé, inclusive.
C, 31.6° to 32.9° Baumé, inclusive.
D, 30.6° to 31.5° Baumé, inclusive.
E, 29.6° to 30.5° Baumé, inclusive.
F, 28.6° to 29.5° Baumé, inclusive.
G, 28.5° and heavier.

Grades from C to G, inclusive, are also separated into "cold-test" and "weak" oils, zero being the standard.

In order to establish these grades an inspector is appointed, who stands between the producers and the transportation company or the purchasers. These oils are for the most part quite dense, and their value varies greatly with the density; the more dense they are the greater the amount of water which they will hold mechanically and the more difficult it is to separate it. The inspector has an office near the central portion of Volcano, and has there instruments for accurately estimating the specific gravity, the water or other sediment, and the temperature at which it will thicken above zero, Fahrenheit, in accordance with the following directions:

> In receiving and making delivery of oils shipped by the company, the water and sediment contained therein shall be determined by mixing an average sample with an equal quantity of benzine, and subject the mixture to 120° F., in a graduated glass vessel, for not less than 6 hours; after which the mixture cools and settles, not less than two hours for light grade, three hours for A grade, four hours for B grade, six hours for C grade, eight hours for D grade, and eighteen hours for heavier grades.

The inspector certifies to the amount of water in the oil upon the back of the receipt issued by the company. This company has also incurred the expense of a very elaborate research upon the coefficient of dilation of oils of different density for each degree of temperature from 0° to 130° F., with the unit at 60°. The compilation was made by Mr. Julius Schubert, of Parkersburg, West Virginia.

The tables, through the kind permission of M. C. C. Church, esq., secretary of the company, are given on pages 111-115. In relation to them Mr. Schubert writes:

> In regard to the expansion table you mentioned in your letter, please let me state that the experiments were made according to a method given by Gay-Lussac, and the formula used for the calculations was also given by the same author.

$$\frac{1+kt}{1+at}=\frac{P-p}{P}$$

Where—

P = weight of the fluid before heating it.
p = weight of the fluid after heating and after the apparent expansion has been removed.
t = change of temperature.
k = coefficient of expansion of the glass=0.000026.
a = coefficient of expansion of the fluid.

The glass used was a liter-bottle with a narrow neck. Instead of finding p, the apparent expansion P—p was directly ascertained by weighing the amount of oil taken out of the bottle. A small pipette was used for removing the oil, and in order to avoid cleaning the pipette so often the following expansion was added to the first one: $(P-p)+(P-p_1)+(P-p_2)+(P-p_3)$, etc.

For every 10° of temperature the expansion of the oil was weighed. The heating was done in a large water-bath very slowly, and the temperature of the water held for some time at the point of the test, so as to be sure that the fluid inside the bottle had reached the same temperature as the water surrounding it.

In the calculation of the table, as sufficient for all practical purposes, I took the coefficient of expansion to be equal or the same during 10° of temperature. As, for instance, in 30° Baumé oil the table shows:

Temperature	Volume		When it should be	
0° temperature,	0.980330	volume, when it should be	0.980330	volume.
	293		287	
1° temperature,	0.980623	volume, when it should be	0.980617	volume.
	293		289	
2° temperature,	0.980916	volume, when it should be	0.980906	volume.
	293		290	
3° temperature,	0.981209	volume, when it should be	0.981196	volume.
	293		291	
4° temperature,	0.981502	volume, when it should be	0.981487	volume.
	293		292	
5° temperature,	0.981795	volume, when it should be	0.981779	volume.
	293		294	
6° temperature,	0.982088	volume, when it should be	0.982073	volume.
	293		295	
7° temperature,	0.982381	volume, when it should be	0.982368	volume.
	293		296	
8° temperature,	0.982674	volume, when it should be	0.982664	volume.
	293		297	
9° temperature,	0.982967	volume, when it should be	0.982961	volume.
	293		299	
10° temperature,	0.983260	volume, when it should be	0.983260	volume.
	306		300	
11° temperature,	0.983566	volume, when it should be	0.983560	volume.
	306		301	
12° temperature,	0.983872	volume, when it should be	0.983861	volume.

I deemed it necessary to call your attention to this fact.

From these experiments it appears that the expansions of the oils increase very perceptibly with the rise of the temperature and also with the decrease of specific gravity; that is, lighter oils expand more readily than heavier oils. The cold-test oils do not seem to differ in this respect from oils which do not stand the cold.

These tables have been found sufficiently accurate for all practical purposes, and are very valuable in handling the great variety of oils produced in that region.

On pages 116 to 133, inclusive, will be found another set of tables, compiled by Dr. S. A. Lattimore, of the University of Rochester, New York, for the use of the Vacuum Oil Company of Rochester, and kindly furnished by those gentlemen for publication. These tables show first the quantity of oil in gallons corresponding to a given weight of oil of different degrees of Baumé's hydrometer, all computed for 60° of temperature. By the use of the first set of tables the volume of a gallon of oil at any temperature between zero and 130° F. can be ascertained if the specific gravity is known at 60° F., while by the use of the second set the number of gallons in a barrel or car of petroleum can be ascertained by weighing if the specific gravity is known at 60° F.

The temperature at which natural petroleums will congeal or become partially solid is an important item in their value for purposes of lubrication, the oils of the Mecca and Franklin districts being particularly valuable in this respect. Great diversity of quality in this particular is observed in the oils of West Virginia, wells in immediate proximity furnishing oils as unlike as possible. The cause of this difference has never been properly investigated, and is only a matter of conjecture; at the same time it is one of the most important questions connected with the heavy-oil trade. Many of the wells of eastern Kentucky yield heavy oils of remarkable and uniformly excellent quality in this respect.

SECTION 2.—THE MANAGEMENT OF PIPE-LINES.

The bulk of the petroleum trade at the present time is conducted through the pipe-lines and their certificates. The entire product of the Belden and the Mecca districts is handled in barrels in small lots. A considerable portion of the Franklin heavy oil and a small part of that of West Virginia is also handled in the same manner. A smaller proportion of the medium and light oils of West Virginia and southern Ohio, as also of the Smith's Ferry district, is sold by the producers direct to the refiners in barrels, and an insignificant proportion of the product of the Oil creek and upper and lower Allegheny districts finds a market in the same way. Such oil is usually rolled upon a frame over a tank, and is emptied from the barrels into the tank. Hence it is called dump oil. Many thousands of barrels of this oil are gathered in the older and nearly exhausted portions of the oil-fields by middlemen, who divide with the producers the cost of piping, paying them about 10 cents per barrel more than the market price. These middlemen dispose of the oil in car-load lots, and usually have a rack for loading one or more cars. A still larger though insignificant portion of the light-oil product is brought out to the railroad by private pipe-lines and is loaded into cars at private racks in small lots of a few car-loads each. This line of business is usually carried on along Oil creek and the Allegheny river between Titusville, Tidioute, and Brady's bend.

The method of handling petroleum by the pipe-lines is substantially the same for all located within the region producing light oils, with perhaps this exception: that while the smaller companies are incorporated and are legally "common carriers", their business is conducted more like that of private individuals, while that of the United Pipe Lines and the Tide-Water Pipe Company is of a more general public nature and interest. The following description of the method of business adopted by the United Pipe Lines will therefore apply to all of the incorporated pipe-line companies: When oil is received from a well into the lines of the company, the amount is ascertained by a joint measurement made by the representative of the owner of the well and the pipe-line, and is passed to the credit of the former on the books of the company, less 3 per cent., to cover losses to points of delivery. Such oil is held in the custody of the line, subject to the order of the owner, precisely like a deposit in bank, and is transferable on a written order. Upon the signature by the owner of a proper order for the whole or any part of his credit balance, whether such balance is obtained by transfer or production, such order will be marked "accepted" by an authorized agent of the company, and thereafter is known in the trade as an "acceptance" or "certificate", and, like a certified check, is negotiable. As the oil exchanges only deal in certificates of the value of 1,000 barrels, they are, so far as is possible, made of that amount; but those for less amounts are sold to the refiners for immediate use, and do not pass into the speculative trade. All persons holding credit balances are entitled, upon payment of proper charges, to have their oil loaded into cars or barges or delivered into tanks, to be disconnected from the lines. All oil, when received from the wells, at once loses its identity and becomes part of the common stock of the line; no holder of a credit balance can therefore claim the identical oil that entered the line from his tank or well.

Producers' credit balances are held free of storage for thirty days, after which time, unless the owner have tankage upon the line, they are chargeable at the rate of 1¼ cents per barrel per month, equal to $12 50 per 1,000 barrels, until removed or transferred. All credit balances obtained by transfer, unless protected by tankage, are subject to the same storage charge until removed. As all the tankage is now practically owned by the lines, this charge is now substantially uniform on all certificates, equal to $150 on 1,000 barrels for one year.

Parties owning iron tanks can have them connected with the line by signing contracts which entitle them to carry oil either in credit balances or certificates, free of storage, to the capacity of their tank, subject to a shrinkage charge of one-fourth per cent. per month, payable in oil. The capacity of such tank is subject to the owner, and can only be temporarily used by the company. Upon demand by the owner of a credit balance for the delivery of his oil, a pipeage charge of 20 cents per barrel must be paid. The term "shipper" is applied in the trade to parties removing oil from the custody of the line. The Tide-Water Pipe Company insures the oil of its patrons; but the United lines mutually insure, as has been before mentioned, and assess the loss upon the holders of certificates.

Since the Tide-Water Pipe Company successfully laid their line from Rixford to Williamsport (now being carried through to Chester, Pennsylvania) another trunk line has been laid to Jersey City. These lines have not made public their charges for conveying oil out of the oil region. The united lines gather oil into tanks and at convenient points of shipment, but do not convey it out of the oil region. The income of these corporations is made up of pipeage fees and storage fees, the former being paid when the oil is removed from the line, and the latter at least once in six months. The term "old oil", used in the exchanges, refers to certificates of pipe-lines on which storage charges have not been paid up to date. Thus, if A holds a certificate of the United Pipe Lines on which storage charges had been paid up to any given previous date, and B bought from him on exchange 1,000 barrels of United oil, storage paid, and A should offer him said certificate, B would say, "That is 'old oil', A; you will have to freshen it." So A would go to the pipe-line office and pay the storage on the certificate up to the date of the transaction, and it would be termed "fresh oil". The line attaches a slip to the certificate showing the date to which storage has been paid.

SECTION 3.—BROKERAGE.

The issuing of certificates by the pipe companies has made speculation in oil, brokerage, and oil exchanges possible to an extent vastly beyond an actual trade in the oil itself. The broker buys or sells for others and charges about $2 50 per thousand barrels for his services. On a market without much fluctuation he also agrees to deliver to customers at a stipulated price a certain amount of oil either on demand or at a fixed time, and receives therefor an amount somewhat less than the storage fees; but he does not purchase until the demand for it is made. If oil falls mean time, he profits; if it rises, he loses; and if the price remains unchanged, he profits to the extent of the money paid him in lieu of storage money that would be paid the pipe company if he purchased the oil. The speculator in oil, therefore, who buys "futures" signs a contract with his broker and pays him his brokerage fees as a buyer and some sum less than $150 per year per thousand barrels of oil. The speculator, who buys certificates if he does not own tankage, pays his broker's fees as a buyer, and also $150 per year per thousand barrels, together with whatever sum may be required to purchase oil to pay the assessments for losses by fire or other accident, and interest on the amount invested. If he owns tankage, in lieu of the $150 per thousand barrels for storage he pays $30 for evaporation and the interest on $260 (the cost of a thousand barrels of tankage), which should be estimated at not less than 20 per cent., together with the other expenses above mentioned.

The fluctuations in the price of petroleum during the census year rendered a speculative investment in the article an object of exciting interest. June 1, 1879, was Sunday. The market opened on the 2d at 74⅜ cents per barrel. It continued to fall, with little disposition to rally, until on the 17th it closed at 64⅜; and after fluctuating between 65 and 68 for four days, it reached 75, and dropped to 69⅜ on the 25th. It hovered about 70 until the 9th of August, when it began to fall, reaching 64⅜ on the 27th. A slight rally held it at about 66 until the 7th of September, when an upward movement began, reaching 96¼ on October 9. It remained near 91 until the 10th of November, when it again moved upward, reaching $1 27½ on the 21st, closing that day at $1 22½. On the following day it ranged between $1 22½ and $1 10⅝, closing at $1 18⅛, from which it rallied, reaching on the 2d of December $1 28⅛. Between the 10th and 18th it ranged between $1 27½ and $1 10, and fluctuated greatly between $1 18 and $1 09 from this time to January 15, 1880, when it went down in three days to $1 05, and steadily declined, with scarce a rally, till, on March 9, it touched 85⅝. It hovered between 85 and 90 till April 6, when it again commenced to decline, reaching 71¼ on the 21st. On the 5th of May it closed at 72½, and by the 26th had again reached the latitude of 93¾, closing on the 31st at 98¾. It will thus be seen that the certificates of oil in tank were worth that year from 64⅜ cents to $1 28⅛ per barrel, and this variation of almost 100 per cent. occurred between August 27 and December 2, an interval of only sixty-eight days. If a man wants a quantity of oil for refining the transaction becomes one of the simplest possible. He buys certificates to the amount required, and calls upon the pipe company to deliver the oil whenever he chooses to provide tanks, cars, or barges to receive it, and after the pipeage of 20 cents per barrel is paid the company delivers the oil.

The price of Franklin first-sand oil averaged during the census year $3 82 per barrel of 42 gallons; that of second-sand crude for the same time varied very slightly from that of third-sand oil. The price of Mecca oil ranged from $7 to $9 per barrel; Smith's Ferry amber oil averaged $1 50 per barrel. The price of West Virginia oils varied from $1 per barrel for light to $9 per barrel for the heaviest oils produced.

The business of the West Virginia Transportation Company, though far smaller in bulk, is much more intricate in detail than that of the large companies controlling the vast interests of the Pennsylvania oil regions. As already mentioned, their oil is so variable in character that its quality has to be determined by an inspector. The following is a copy of the certificate used by this company, and the rules of the company printed upon the back of it:

Dept. C, No. 2694.

THE WEST VIRGINIA TRANSPORTATION COMPANY,
Parkersburg, W. Va., August 8, 1881.

Received from Excelsior well, West Va. O. & O. L. Co., tract for account of royalty, under and subject to the charges, terms, and conditions on the back of this receipt, as a part thereof, No. —— barrels (of 40 gallons each) of 32$\frac{3}{10}$° crude oil, for transportation through pipe-line in bulk with C grade (31$\frac{6}{10}$ to 32$\frac{9}{10}$ gravity) to our tanks at Volcano, West Virginia, and for delivery by oil of like grade, or gravity, in lots of 500 barrels or over at Parkersburg, West Virginia, (unavoidable delays excepted), to the order of Geo. Washington, at the rate of 35 cents per barrel, including therein all charges for inspecting, grading, and measuring said oil, and certifying in the receipt therefor the amount, grade, and gravity, and liability under and by reason of said certificate.

THE WEST VIRGINIA TRANSPORTATION CO.,
By M. C. C. CHURCH, *Secretary*.

Attest: CHAS. A. BUKEY.

(Stamped across the face:) Canceled August 1, 1881.
(On the margin:) Not negotiable unless signed by the secretary of the company.

FORM NO. 5.

The terms and conditions upon which the within mentioned oil is held by the West Virginia Transportation Company are as follows:

In receiving the within oil, the water and sediment contained therein, as per the following inspector's certificate, have been first deducted, and the following percentages of oil have been reserved to cover losses for evaporation and waste in receiving, transporting, and delivering the same; the within receipt, therefore, covers the net amount only. On light and A grades two and one-half per cent.; on B and C grades two per cent.; and on heavier oils one and one-half per cent. (See below for variation in case of local and special shipments.)

I certify that I have inspected the within oil, and that it contained ½ per cent. of water and sediment at the time of shipment.

HENRY CASKIN, *Inspector.*

The company shall not be responsible or liable for loss by fire or unavoidable accidents; but any such loss shall be assessed, *pro rata*, upon the total amount of outstanding certificates of oil, of like grade of the within, held by the company at the time such loss may occur.

The company shall have a lien upon all the within mentioned oil for all charges mentioned in this receipt. These charges shall be made upon the net quantity of oil received by the West Virginia Transportation Company (said quantity being mentioned in the face of this receipt), and the computation thereof to be made from the date of this receipt.

The following percentages of the net amount of oil received shall be deducted to cover losses by evaporation when held in tankage, to wit: On light and A grades, one per cent. per month or part of a month; on B and C grades, three-fourths of one per cent. per month or part of a month; on heavier oils, one-half of one per cent. per month or part of a month.

Monthly statements of the company's oil account will be made; and any gains arising from the above reservations, on account of waste and evaporation, will be returned, *pro rata*, in certificate oil, to shippers, to July 1 of each and every year during the continuance of this arrangement.

Freight and other charges are due and payable on receipt of the oil in the company's tankage at Volcano and Cochran's, West Virginia, and at Petrolia, Ohio. If said charges are not settled within fifteen days from the date of this receipt, storage will be charged at the rate of 2 cents per barrel per month or part of a month from said date. If the oil is not removed within three months from the date aforesaid, the company shall have right to remove and store the same at the expense of the consignee, and the right to sell said oil, or such part thereof as may be necessary, at public auction to the highest bidder, to pay the advances made and charges due to it, together with the costs of sale. Such sale to be made upon the premises of the company upon at least ten days' notice by advertising in newspapers published at Parkersburg, West Virginia, and Marietta, Ohio.

In receiving and making delivery of oils shipped by the company, the water and sediment contained therein shall be determined by mixing an average sample with an equal quantity of benzine, and subject the mixture to 120° F., in a graduated glass vessel, for not less than 6 hours, after which the mixture cools and settles not less than two hours for light grade, 3 hours for A grade, 4 hours for B grade, 6 hours for C grade, 8 hours for D grade, and 18 hours for heavier grades.

No allowance made on account of condition in making delivery of the within oil.

Note.—The foregoing applies to regular shipments, to wit: Shipments net by pipe-line to Parkersburg, West Virginia, or to Petroleum, West Virginia, or to Petrolia, Ohio, or to Cochran's, West Virginia.

SPECIAL SHIPMENTS.—The company will take special shipments of oil, in lots of 500 barrels or over, under the conditions expressed herein, except as modified as follows: First. Tankage shall be furnished at the point of destination and possession retained by the company until the final delivery of the shipment. Second. The company delivers all the oil, water, and sediment received by it and guarantees that the loss of actual oil shall not exceed the above reservations. Third. Special shipment certificates will be issued and charges will be made upon the gross amount of oil, water, and sediment received for transportation.

Note.—Special shipments are shipments by pipe-line, in gross, to Parkersburg, West Virginia, or to Petroleum, West Virginia.

LOCAL SHIPMENTS.—The company will take local shipments of oil, in lots of not less that 50 barrels, charging therefor at the rate of 10 cents per barrel. Local shipments to be under the same conditions in other respects as expressed above for special shipments.

Note.—Local shipments are shipments made in gross, and are confined to points in the Volcano oil district. When regular shipments are stopped *in transitu* they become local shipments, and charges will be made on the gross amount received at the well, and not on the net amount, as per face of regular shipment certificates. In all such cases said certificates must be surrendered and canceled and local shipment certificates issued for the gross amount at the well, as aforesaid; the delivery as to amount to be made, however, according to the terms of the regular shipment certificates surrendered.

The acceptance and retention of this receipt shall be regarded as an agreement on the part of the owner of said oil to all its terms and conditions, which shall be equally binding on all subsequent holders hereof.

Deliver to the order of ——.

The charges for pipeage from the wells in Volcano district to Parkersburg, West Virginia, are 35 cents per barrel of 40 gallons each; to the Baltimore and Ohio railroad, 30 cents; to Cochran's Landing, Ohio river, 30 cents; and local shipments to points within the oil districts, 10 cents. From Cow run, Ohio, to Petrolia, on the Ohio river, the rate is 30 cents. If oil remains in their tankage over 15 days, the charge for storage is 2 cents per barrel per month or part of a month from date, unless the freight charges are paid when storage is remitted. So far as the principal and general use of the certificates of this company is concerned, they become what they indicate—mere mediums between the consignor and consumer or refiner. Sometimes, however, they are used by the producers as collateral security for their notes in the local banks. In some instances also they have been purchased by investors as a speculation and held for a rising market, but such cases are exceptional.

SECTION 4.—PETROLEUM AS AN ARTICLE OF FOREIGN COMMERCE.

The foreign trade in petroleum centers in New York, Philadelphia, and Baltimore, with a very large proportion of the whole in New York. The exports consist of crude petroleum, the different varieties of illuminating oil, naphtha, and residuum. This trade is largely controlled by the New York produce exchange. The following rules, which indicate the general methods upon which the business is conducted, are taken from their report for 1879:

CRUDE PETROLEUM.

RULE 4. Crude petroleum shall be understood to be pure, natural oil, neither steamed nor treated, free from water, sediment, or any adulteration, of the gravity of 43° to 48° Baumé.

RULE 5. When crude petroleum is sold in bulk, the quantity shall be ascertained by tank measurement at the time of delivery.

RULE 6. Crude petroleum in barrels shall be sold by weight at the rate of 6½ pounds net to the gallon.

RULE 7. In the absence of any stipulation, crude petroleum, when sold in barrels, shall be understood to mean, so far as regards packages, such packages as were originally refined petroleum barrels, whose last contents was crude petroleum, refined petroleum, or naphtha.

RULE 8. When contracts for crude petroleum call for second-hand refined petroleum barrels (*i. e.*, barrels whose last contents have been refined petroleum or naphtha) the sellers shall have the privilege of substituting new barrels, but they shall be glued.

RULE 9. The weighing and verification of crude petroleum shall be governed by the rules applicable thereto under the head of refined petroleum.

REFINED PETROLEUM.

RULE 10. Refined petroleum shall be standard white, or better, with a burning test of 110° F. or upward, and of a specific gravity not below 45° Baumé.

RULE 11. The burning test of refined petroleum shall be determined by the use of the Saybolt electric instrument, and shall be operated in arriving at a result as follows: In 110° and upward the flashing points, after the first flash (which will generally occur between 90° and 95°), shall be taken at 95°, 100°, 104°, 108°, 110°, 112°, and 115°; in 120° and upward, after first flash, at 100°, 105°, 110°, 115°, 118°, 120°, 122°, and 125°; in 130° and upward, every 5° until burning point is reached.

RULE 12. When refined petroleum is sold in bulk, the quantity shall be ascertained by measurement on the decks of the tank-boats.

RULE 13. Refined petroleum shall be delivered in blue, well-painted barrels, with white heads. Barrels shall be well glued and filled within 1 or 2 inches of the bung.

RULE 14. Refined petroleum in barrels shall be sold by weight at the rate of 6½ pounds net to the gallon.

RULE 15. The tares of refined petroleum in barrels shall be weighed by half pounds and gross weight by pounds.

RULE 16. The gross weight of packages for refined petroleum shall be not less than 360 pounds nor more than 415 pounds, and the actual gross weight shall be plainly marked thereon.

RULE 17. Barrels shall be made of well-seasoned white-oak timber, and shall be hooped not lighter than as follows: Either with six iron hoops, the head hoop 1¾ inches wide, No. 16 gauge, English standard, the quarter hoop 1½ inches wide, No. 17 gauge, and the bilge-hoop 1¾ inches wide, No. 16 gauge; or with eight iron hoops, the head-hoop 1¾ inches wide, No. 17 gauge, the collar-hoop 1½ inches wide, No. 17 gauge, the quarter-hoop 1½ inches wide, No. 18 gauge, and the bilge-hoop 1½ inches wide, No. 18 gauge. But all old barrels of which the gross weight is less than 395 pounds may be hooped with six iron hoops 1½ inches wide, excepting the chine hoop, which shall be 1¾ inches wide.

RULE 18. Buyers may test, at their own expense, the correctness of the gross weight or gauge of the whole or part of any lot delivered, and the average shortage found on a portion of not less than 10 per cent. shall be taken as the average amount to be deducted from the lot.

RULE 19. The tare shall be plainly marked upon each barrel before it is filled. Buyers may test the accuracy of the tare so marked to the extent of 5 per cent. of the lot, and the average difference between the tare thus ascertained and the marked tare on the barrels tested shall be accepted as the average difference on the entire lot. Any excess of tare so discovered shall be allowed buyer.

NAPHTHA.

RULE 20. Naphtha shall be water-white and sweet, and of gravity of from 68° to 73° Baumé.

RULE 21. When naphtha is sold in bulk, the quantity shall be ascertained by measurement on the decks of the tank-boats.

RULE 22. Naphtha in barrels shall be sold by weight at the rate of 5¾ pounds net to the gallon.

RULE 23. Barrels containing naphtha shall be painted blue, with white heads, and be well glued.

RULE 24. Naphtha shall be weighed, and may be tested by the buyer, as provided in the foregoing rules relating to refined petroleum.

RESIDUUM.

RULE 25. Residuum shall be understood to be the refuse from the distillation of crude petroleum, free from coke and water and from any foreign impurities, and of gravity from 16° to 21° Baumé.

RULE 26. Residuum, when sold in barrels, shall be sold by weight, at the rate of 7½ pounds net per gallon.

RULE 27. Residuum shall be weighed, and may be tested by the buyer, as provided in the foregoing rules relating to refined petroleum.

EMPTY BARRELS.

RULE 28. Unless otherwise stipulated, empty barrels shall be understood to have last contained either refined petroleum or naphtha.

RULE 29. Barrels shall be classified according to the use for which they are fitted, as follows:

First class shall include all barrels which, if properly coopered, would be fit to carry refined petroleum or naphtha.

Second class shall include barrels which are unfit for refined petroleum or naphtha, but which would, if properly coopered, be fit for crude petroleum.

Third class shall include such barrels as are unfit for either crude, refined petroleum, or naphtha, but which can be used for residuum, if properly coopered.

RULE 30. When barrels which would otherwise be first class have been injured by sand, mold, or water, they shall be placed in the second class.

RULE 32. When barrels have been filled with crude petroleum, and steamed out after shipment to Europe and used for refined oil, such packages shall be placed in the second class.

RULE 33. All empty barrels must have six hoops, and be delivered in form, shooks or staves not being a good delivery.

CONTRACTS AND DELIVERIES.

RULE 35. All deliveries and contracts for delivery of petroleum and its products under these rules shall be of the production of the United States, unless otherwise specified.

RULE 36. All settlements of contracts for refined petroleum and naphtha shall be on the following basis: In barrels, on 50 gallons; in bulk, on 45 gallons. All settlements of contracts for crude petroleum shall be on the following basis: In barrels, on 48 gallons; in bulk, on 42 gallons.

RULE 37. All cooperage shall be in prime shipping order. Tar and pitch barrels shall be excluded, except for residuum.

RULE 38. When the capacity of the vessel exceeds or falls short of the amount specified in the contract, including the margin, then the specified amount shall be delivered. In determining the capacity of the vessel, barrels of 50 net gallons capacity in case of refined petroleum and naphtha, barrels of 48 net gallons capacity in case of crude petroleum, and barrels of 45 net gallons capacity in case of residuum shall be the basis for settlement.

The inspection of petroleum and its products for export is an important business in New York city, Philadelphia, and Baltimore. Mr. A. Bourgougnon has read before the American Chemical Society several papers relating to this inspection. He refers to the fact that the petroleum of the New York market is a mixture of oils from a great many wells, and remarks that the specific gravity of the New York crude oil ranges from 0.790 to 0.800 = 48° to 46° B. at 15° C.

The coefficient of expansion of the crude oil varies from 0.00082 to 0.00086, according to the gravity of the oil. For the products of distillation the following can be generally adopted:

Under 0.700 gravity at 15° C	0.00090
0.700 to 0.750 gravity at 15° C	0.00085
0.750 to 0.800 gravity at 15° C	0.00080
0.800 gravity at 15° C	0.00070

The knowledge of these coefficients is important, as it aids in calculating the empty space which must be allowed in the vessels containing the oil. This space will be—

$$V. K. 50,$$

V representing the volume of the oil, K the coefficient of expansion, and 50 the number of degrees of temperature through which the oil may change.

Generally the inspectors examine the density, the odor, and how the oil feels with the fingers, and make a fractional distillation in tenth parts, giving a report stating that the oil does not contain more than 17 per cent. of naphtha. He states further that the separation of the distillate into hundredths instead of tenths is much to be preferred, as the proportion of naphtha can then be determined with exactness; "and this determination is very important to the buyer, since the crude oil is taxed in foreign countries according to the quantity of naphtha contained in it."

The crude oil of the New York market will generally furnish from 12 to 15 per cent. of naphtha at 0.700 specific gravity, 9 to 12 per cent. of benzine at 0.730 specific gravity, and about 60 per cent. of burning oil at 0.795 specific gravity. The residuum contains 2½ per cent. of dry paraffine, calculated for the quantity of oil submitted to distillation. (*a*)

In another communication he thus describes an ingeniously contrived instrument for determining the amount of naphtha of 0.700 gravity in crude petroleum:

I employ an instrument made on the same principle and of the same shape as an hydrometer, which I call a *naphthometer*. To make the graduation of this instrument I proceed as follows: The specific gravity of commercial naphtha being 0.700 at 15° C., it is first necessary to have such naphtha. This naphtha being at a temperature of 15° C., the naphthometer is immersed in it, and on the stem at the point of intersection of the liquid the number 15 is written. The same naphtha is brought to a temperature of 20° C., and on the stem, as above, the number 20 is written; the temperature of the naphtha is again increased to 25° C., and the number 25 is written on the stem at the point of intersection, and so on, in order that the temperature indicated by the thermometer (when immersed in naphtha of 0.700 at 15° C.) will be always in accordance with the figures marked on the stem. For example, if I have a sample of naphtha of which the density is 0.700 at 15° C., but supposing that the actual temperature be 20° C., the naphthometer will indicate 20 both by the thermometer and on the stem at the point of intersection with the liquid. Now, to determine the percentage of naphtha in crude petroleum, I distill, say 300 c. c., and collect the distillate in a glass cylinder divided into c. c., in which glass the naphthometer has been previously placed. The temperature of the distillate, and if, *e. g.*, the temperature be 25° C., the distillation is continued until the point marked 25 on the stem intersects with the liquid. At this moment the naphtha has a specific gravity of 0.700 at 15° C., as I have verified by several experiments. Removing the naphthometer from the jar, cooling to 15° C., and reading the number of c. c. obtained, and dividing by 3, I obtain finally the percentage of naphtha at 0.700 density and at the temperature of 15° C. contained in the crude oil. (*b*)

The increase in the bulk of petroleum and of all its products, due to an increase of temperature, occasions a great deal of trouble in measuring these articles in bulk. In barrels and small packages the difficulty is obviated by weighing. Preisser, of Rouen, in 1840, investigated a case in which a certain amount of oil (seed and fish) was stored in winter and measured in summer, when an excess was discovered, and the parties storing were charged with fraud. He found that the oil increased in volume at a certain ratio for each degree of temperature. (*c*) M. Henri St. Claire Deville first stated that American petroleum increases in bulk 0.01 for every 10° C. Later it has been discovered that the ratio of expansion varies with the specific gravity of the oil and also with the temperature. The table on pages 111 to 115, inclusive, has been computed for the specific gravity of crude oil up to 45° B.

a 7. Am. Chem., vii, 81. *b* *Ibid.*, p. 123. *c* *Jour. F. Inst.*, xxix, 130.

This does not embrace illuminating oils or naphthas, but is approximately correct for the dense oils belo
Mr. Gustavus Pile offers the following suggestion of a method of universal application to crude petroleum a petroleum products: (*a*)

I was asked a short time ago by a gentleman in the coal-oil trade to furnish him with some sort of apparatus with which h readily estimate the number of gallons of oil there would be in a tank gauged at any temperature if the temperature were reduced F. The rate of expansion of most of the petroleum products being considerable, the difference in measurement at various tempe often becomes too great to be unnoticed. In the case of benzine of 68° B., the expansion from 30° to 90° F. amounted to 50 part 1,000. The solution of this problem appears to be best made by observing the specific gravity as it would stand at different tempera and calculating from the variation in the gravity the amount of expansion in bulk. If we have gauged a tank holding oil a it to hold, at 90° temperature, 12,000 gallons, and desire to know how much that would measure if reduced to 60° temperature, w first note the gravity at the two temperatures, 60° and 90°, and the calculation will then be as follows: Say the gravity at 90° = and at 60° = 0.8025. The gravity at 90° is to be divided by the gravity at 60°, thus $\frac{7899}{8025}$, which will give the measure at 60° of one and by multiplying this by 12,000, $\frac{7899}{8025} + 12,000 = 11,812$ gallons, we have the measure at 60° of the whole amount. The difference gallons between the measure at 60° and that at 90° expresses the expansion caused by that increase of temperature.

In order to obtain correct results by this method, it would be necessary to use hydrometers made with a specific gravity sca with the degrees sufficiently far apart to be able to read to single degrees, or also to use a specific gravity bottle, which, of cours always give the best result.

I am not acquainted with any method that may be in use among dealers, but the plan here suggested will give accurate concl and where it is found necessary to be particular can be used with confidence.

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a *Oil and Drug News.*

TABLE OF EXPANSION OF THE WEST VIRGINIA NATURAL OILS.

[*GRAVITIES* 28° *TO* 45°, *FROM ZERO TO* 130° *F., WITH THE UNIT AT* 60° *TEMPERATURE.*]

Calculated by JUL. SCHUBERT, *Engineer.*

The expansion of the West Virginian natural oils is, as the following table shows, by no means very small, and has in a large number of cases worked to the disadvantage of both producers and dealers. It therefore became desirable to have the expansion of the oils established, and carefully conducted experiments, according to the rule laid down by Professor Gay-Lussac for testing the expansion of liquids, and calculations made corresponding to the formula of the same author, have furnished the following table.

The coefficient of expansion of the glass entering into the calculation has been adopted as being 0.000026.

The expansion of the oils increases with the temperature and varies with the gravity. The higher oils expand faster than the heavier oils within the same change of temperature. It became necessary, therefore, to establish the scale of expansion for each gravity from 28° to 45°.

As the gravity is measured at 60° temperature, the unit for the volume of the oil has also been taken at 60° F.

The quantity of oil at 60° temperature should be the guide in all business transactions with the West Virginian natural oils.

RULES FOR USE OF THE TABLE.—In order to find the quantity of oil at 60° temperature: Divide the quantity of the oil by the figure found in the table corresponding both to gravity and temperature of the oil.

For instance: 75.63 barrels of 35° oil, measured at a temperature of 26°, would be:

$$\frac{75.63}{0.987394} = 76.59 \text{ barrels of } 35° \text{ oil at } 60°.$$

Or, 81.34 barrels of 33° oil, measured at a temperature of 88°, would be:

$$\frac{81.34}{1.011566} = 80.41 \text{ barrels of } 33° \text{ oil at } 60° \text{ temperature.}$$

TABLE OF EXPANSION OF THE WEST VIRGINIA NATURAL OILS.

Degrees of temperature. (*F.*)	DEGREES OF GRAVITY.								
	28°.	29°.	30°.	31°.	32°.	33°.	34°.	35°.	36°.
Zero.	0.980810	0.980570	0.980330	0.980060	0.979770	0.979470	0.979170	0.978870	0.978570
1	0.981095	0.980859	0.980623	0.980357	0.980071	0.979776	0.979481	0.979186	0.978891
2	0.981380	0.981148	0.980916	0.980654	0.980372	0.980082	0.979792	0.979502	0.979212
3	0.981665	0.981437	0.981209	0.980951	0.980673	0.980388	0.980103	0.979818	0.979533
4	0.981950	0.981726	0.981502	0.981248	0.980974	0.980694	0.980414	0.980134	0.979854
5	0.982235	0.982015	0.981795	0.981545	0.981275	0.981000	0.980725	0.980450	0.980175
6	0.982520	0.982304	0.982088	0.981842	0.981576	0.981306	0.981036	0.980766	0.980496
7	0.982805	0.982593	0.982381	0.982139	0.981877	0.981612	0.981347	0.981082	0.980817
8	0.983090	0.982882	0.982674	0.982436	0.982178	0.981918	0.981658	0.981398	0.981138
9	0.983375	0.983171	0.982967	0.982733	0.982479	0.982224	0.981969	0.981714	0.981459
10	0.983660	0.983460	0.983260	0.983030	0.982780	0.982530	0.982280	0.982030	0.981780
11	0.983958	0.983762	0.983566	0.983340	0.983095	0.982850	0.982605	0.982360	0.982115
12	0.984256	0.984064	0.983872	0.983650	0.983410	0.983170	0.982930	0.982690	0.982450
13	0.984554	0.984366	0.984178	0.983960	0.983725	0.983490	0.983255	0.983020	0.982785
14	0.984852	0.984668	0.984484	0.984270	0.984040	0.983810	0.983580	0.983350	0.983120
15	0.985150	0.984970	0.984790	0.984580	0.984355	0 984130	0.983905	0.983680	0.983455
16	0.985448	0.985272	0.985096	0.984890	0.984670	0.984450	0.984230	0.984010	0.983790
17	0.985746	0.985574	0.985402	0.985200	0.984985	0.984770	0.984555	0.984340	0.984125
18	0.986044	0.985876	0.985708	0.985510	0.985300	0.985090	0.984880	0.984670	0.984460
19	0.986342	0.986178	0.986014	0.985820	0.985615	0.985410	0.985205	0.985000	0.984795
20	0.986640	0.986480	0.986320	0.986130	0.985930	0.985730	0.985530	0.985330	0.985130
21	0.986952	0.986796	0.986640	0.986454	0.986259	0.986064	0.985869	0.985674	0.985479
22	0.987264	0.987112	0.986960	0.986778	0.986588	0.986398	0.986208	0.986018	0.985828
23	0.987576	0.987428	0.987280	0.987102	0.986917	0.986732	0.986547	0.986362	0.986177
24	0.987888	0.987744	0.987600	0.987426	0.987246	0.987066	0.986886	0.986706	0.986526
25	0.988200	0.988060	0.987920	0.987750	0.987575	0.987400	0.987225	0.987050	0.986875
26	0.988512	0.988376	0.988240	0.988074	0.987904	0.987734	0.987564	0.987394	0.987224
27	0.988824	0.988692	0.988560	0.988398	0.988233	0.988068	0.987903	0.987738	0.987573
28	0.989136	0.989008	0.988880	0.988722	0.988562	0.988402	0.988242	0.988082	0.987922
29	0.989448	0.989324	0.989200	0.989046	0.988891	0.988736	0.988581	0.988426	0.988271
30	0.989760	0.989640	0.989520	0.989370	0.989220	0.989070	0.988920	0.988770	0.988620
31	0.990086	0.989970	0.989854	0.989709	0.989564	0.989419	0.989274	0.989120	0.988984
32	0.990412	0.990300	0.990188	0.990048	0.989908	0.989768	0.989628	0.989488	0.989348
33	0.990738	0.990630	0.990522	0.990387	0.990252	0.990117	0.989982	0.989847	0.989712
34	0.991064	0.990960	0.990856	0.990726	0.990596	0.990466	0.990336	0.990206	0.990076
35	0.991390	0.991290	0.991190	0.991065	0.990940	0.990815	0.990690	0.990565	0.990440
36	0.991716	0.991620	0.991524	0.991404	0.991284	0.991164	0.991044	0.990924	0.990804
37	0.992042	0.991950	0.991858	0.991743	0.991628	0.991513	0.991398	0.991283	0.991168
38	0.992368	0.992280	0.992192	0.992082	0.991972	0.991862	0.991752	0.991642	0.991532
39	0.992694	0.992610	0.992526	0.992421	0.992316	0.992211	0.992106	0.992001	0.991896
40	0.993020	0.992940	0.992860	0.992760	0.992660	0.992560	0.992460	0.992360	0.992260
41	0.993361	0.993285	0.993209	0.993114	0.993019	0.992924	0.992829	0.992734	0.992639
42	0.993702	0.993630	0.993558	0.993468	0.993378	0.993288	0.993198	0.993108	0.993018
43	0.994043	0.993975	0.993907	0.993822	0.993737	0.993652	0.993567	0.993482	0.993397
44	0.994384	0.994320	0.994256	0.994176	0.994096	0.994016	0.993936	0.993856	0.993776
45	0.994725	0.994665	0.994605	0.994530	0.994455	0.994380	0.994305	0.994230	0.994155
46	0.995066	0.995010	0.994954	0.994884	0.994815	0.994744	0.994674	0.994604	0.994534
47	0.995407	0.995355	0.995303	0.995238	0.995173	0.995108	0.995073	0.994978	0.994913
48	0.995748	0.995700	0.995652	0.995592	0.995532	0.995472	0.995412	0.995352	0.995292
49	0.996089	0.996045	0.996001	0.995946	0.995891	0.995836	0.995781	0.995726	0.995671
50	0.996430	0.996390	0.996350	0.996300	0.996250	0.996200	0.996150	0.996100	0.996050
51	0.996787	0.996751	0.996715	0.996670	0.996625	0.996580	0.996535	0.996490	0.996445
52	0.997144	0.997112	0.997080	0.997040	0.997000	0.996960	0.996920	0.996880	0.996840
53	0.997501	0.997473	0.997445	0.997410	0.997375	0.997340	0.997305	0.997270	0.997235
54	0.997858	0.997834	0.997810	0.997780	0.997750	0.997720	0.997690	0.997660	0.997630
55	0.998215	0.998195	0.998175	0.998150	0.998125	0.998100	0.998075	0.998050	0.998025
56	0.998572	0.998556	0.998540	0.998520	0.998500	0.998480	0.998460	0.998440	0.998420
57	0.998929	0.998917	0.998905	0.998890	0.998875	0.998860	0.998845	0.998830	0.998815
58	0.999286	0.999278	0.999270	0.999260	0.999250	0.999240	0.999230	0.999220	0.999210
59	0.999643	0.999639	0.999635	0.999630	0.999625	0.999620	0.999615	0.999610	0.999605
60	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
61	1.000374	1.000378	1.000382	1.000387	1.000392	1.000397	1.000402	1.000407	1.000412
62	1.000748	1.000756	1.000764	1.000774	1.000784	1.000794	1.000804	1.000814	1.000824
63	1.001122	1.001134	1.001146	1.001161	1.001176	1.001191	1.001206	1.001221	1.001236
64	1.001496	1.001512	1.001528	1.001548	1.001568	1.001588	1.001608	1.001628	1.001648
65	1.001870	1.001890	1.001910	1.001935	1.001960	1.001985	1.002010	1.002035	1.002060

TABLE OF EXPANSION OF THE WEST VIRGINIA NATURAL OILS—Continued.

DEGREES OF GRAVITY.									Degrees of temperature. (*F.*)
37°.	38°.	39°.	40°.	41°.	42°.	43°.	44°.	45°.	
0.978210	0.977850	0.977490	0.977130	0.976770	0.976390	0.976020	0.975660	0.975240	Zero.
0.978537	0.978183	0.977829	0.977475	0.977121	0.976747	0.976383	0.976029	0.975616	1
0.978864	0.978516	0.978168	0.977820	0.977472	0.977104	0.976746	0.976398	0.975992	2
0.979191	0.978849	0.978507	0.978165	0.977823	0.977461	0.977109	0.976767	0.976368	3
0.979518	0.979182	0.978846	0.978510	0.978174	0.977818	0.977472	0.977136	0.976744	4
0.979845	0.979515	0.979185	0.978855	0.978525	0.978175	0.977835	0.977505	0.977120	5
0.980172	0.979848	0.979524	0.979200	0.978876	0.978532	0.978198	0.977874	0.977496	6
0.980499	0.980181	0.979863	0.979545	0.979227	0.978889	0.978561	0.978243	0.977872	7
0.980826	0.980514	0.980202	0.979890	0.979578	0.979246	0.978924	0.978612	0.978248	8
0.981153	0.980847	0.980541	0.980235	0.979929	0.979603	0.979287	0.978981	0.978624	9
0.981480	0.981180	0.980880	0.980580	0.980280	0.979960	0.979650	0.979350	0.979000	10
0.981821	0.981527	0.981233	0.980939	0.980645	0.980331	0.980027	0.979733	0.979390	11
0.982162	0.981874	0.981586	0.981298	0.981010	0.980702	0.980404	0.980116	0.979780	12
0.982503	0.982221	0.981939	0.981657	0.981375	0.981073	0.980781	0.980499	0.980170	13
0.982844	0.982568	0.982292	0.982016	0.981740	0.981444	0.981158	0.980882	0.980560	14
0.983185	0.982915	0.982645	0.982375	0.982105	0.981815	0.981535	0.981265	0.980950	15
0.983526	0.983262	0.982998	0.982734	0.982470	0.982186	0.981912	0.981648	0.981340	16
0.983867	0.983609	0.983351	0.983093	0.982835	0.982557	0.982289	0.982031	0.981730	17
0.984208	0.983956	0.983704	0.983452	0.983200	0.982928	0.982666	0.982414	0.982120	18
0.984549	0.984303	0.984057	0.983811	0.983565	0.983299	0.983043	0.982797	0.982510	19
0.984890	0.984650	0.984410	0.984170	0.983930	0.983670	0.983420	0.983180	0.982900	20
0.985245	0.985011	0.984777	0.984543	0.984309	0.984055	0.983811	0.983577	0.983304	21
0.985600	0.985372	0.985144	0.984916	0.984688	0.984440	0.984202	0.983974	0.983708	22
0.985955	0.985733	0.985511	0.985289	0.985067	0.984825	0.984593	0.984371	0.984112	23
0.986310	0.986094	0.985878	0.985662	0.985446	0.985210	0.984984	0.984768	0.984516	24
0.986665	0.986455	0.986245	0.986035	0.985825	0.985595	0.985375	0.985165	0.984920	25
0.987020	0.986816	0.986612	0.986408	0.986204	0.985980	0.985766	0.985562	0.985324	26
0.987375	0.987177	0.986979	0.986781	0.986583	0.986365	0.986157	0.985959	0.985728	27
0.987730	0.987538	0.987346	0.987154	0.986962	0.986750	0.986548	0.986356	0.986132	28
0.988085	0.987899	0.987713	0.987527	0.987341	0.987135	0.986939	0.986753	0.986536	29
0.988440	0.988260	0.988080	0.987900	0.987720	0.987520	0.987330	0.987150	0.986940	30
0.988810	0.988636	0.988462	0.988288	0.988114	0.987920	0.987736	0.987562	0.987359	31
0.989180	0.989012	0.988844	0.988676	0.988508	0.988320	0.988142	0.987974	0.987778	32
0.989550	0.989388	0.989226	0.989064	0.988902	0.988720	0.988548	0.988386	0.988197	33
0.989920	0.989764	0.989608	0.989452	0.989296	0.989120	0.988954	0.988798	0.988616	34
0.990290	0.990140	0.989990	0.989840	0.989690	0.989520	0.989360	0.989210	0.989035	35
0.990660	0.990516	0.990372	0.990228	0.990084	0.989920	0.989766	0.989622	0.989454	36
0.991030	0.990892	0.990754	0.990616	0.990478	0.990320	0.990172	0.990034	0.989873	37
0.991400	0.991268	0.991136	0.991004	0.990872	0.990720	0.990578	0.990446	0.990292	38
0.991770	0.991644	0.991518	0.991392	0.991266	0.991120	0.990984	0.990858	0.990711	39
0.992140	0.992020	0.991900	0.991780	0.991660	0.991520	0.991390	0.991270	0.991130	40
0.992525	0.992411	0.992297	0.992183	0.992069	0.991936	0.991812	0.991698	0.991565	41
0.992910	0.992802	0.992694	0.992586	0.992478	0.992352	0.992234	0.992126	0.992000	42
0.993295	0.993193	0.993091	0.992989	0.992887	0.992768	0.992656	0.992554	0.992435	43
0.993680	0.993584	0.993488	0.993392	0.993296	0.993184	0.993078	0.992982	0.992870	44
0.994065	0.993975	0.993885	0.993795	0.993705	0.993600	0.993500	0.993410	0.993305	45
0.994450	0.994366	0.994282	0.994198	0.994114	0.994016	0.993922	0.993838	0.993740	46
0.994835	0.994757	0.994679	0.994601	0.994523	0.994432	0.994344	0.994266	0.994175	47
0.995220	0.995148	0.995076	0.995004	0.994932	0.994848	0.994766	0.994694	0.994610	48
0.995605	0.995539	0.995473	0.995407	0.995341	0.995264	0.995188	0.995122	0.995045	49
0.995990	0.995930	0.995870	0.995810	0.995750	0.995680	0.995610	0.995550	0.995480	50
0.996391	0.996337	0.996283	0.996229	0.996175	0.996112	0.996049	0.995995	0.995932	51
0.996792	0.996744	0.996696	0.996648	0.996600	0.996544	0.996488	0.996440	0.996384	52
0.997193	0.997151	0.997109	0.997067	0.997025	0.996976	0.996927	0.996885	0.996836	53
0.997594	0.997558	0.997522	0.997486	0.997450	0.997408	0.997366	0.997330	0.997288	54
0.997995	0.997965	0.997935	0.997905	0.997875	0.997840	0.997805	0.997775	0.997740	55
0.998396	0.998372	0.998348	0.998324	0.998300	0.998272	0.998244	0.998220	0.998192	56
0.998797	0.998779	0.998761	0.998743	0.998725	0.998704	0.998683	0.998665	0.998644	57
0.999198	0.999186	0.999174	0.999162	0.999150	0.999136	0.999122	0.999110	0.999096	58
0.999599	0.999593	0.999587	0.999581	0.999575	0.999568	0.999561	0.999555	0.999548	59
1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	60
1.000418	1.000424	1.000430	1.000436	1.000442	1.000449	1.000456	1.000463	1.000470	61
1.000836	1.000848	1.000860	1.000872	1.000884	1.000898	1.000912	1.000926	1.000940	62
1.001254	1.001272	1.001290	1.001308	1.001326	1.001347	1.001368	1.001389	1.001410	63
1.001672	1.001696	1.001720	1.001744	1.001768	1.001796	1.001824	1.001852	1.001880	64
1.002090	1.002120	1.002150	1.002180	1.002210	1.002245	1.002280	1.002315	1.002350	65

TABLE OF EXPANSION OF THE WEST VIRGINIA NATURAL OILS—Continued.

Degrees of temperature. (F.)	DEGREES OF GRAVITY.								
	28°.	29°.	30°.	31°.	32°.	33°.	34°.	35°.	36°.
66	1.002244	1.002268	1.002292	1.002322	1.002352	1.002382	1.002412	1.002442	1.002472
67	1.002618	1.002646	1.002674	1.002709	1.002744	1.002779	1.002814	1.002849	1.002884
68	1.002992	1.003024	1.003056	1.003096	1.003136	1.003176	1.003216	1.003256	1.003296
69	1.003366	1.003402	1.003438	1.003483	1.003528	1.003573	1.003618	1.003663	1.003708
70	1.003740	1.003780	1.003820	1.003870	1.003920	1.003970	1.004020	1.004070	1.004120
71	1.004131	1.004175	1.004219	1.004274	1.004329	1.004384	1.004439	1.004495	1.004550
72	1.004522	1.004570	1.004618	1.004678	1.004738	1.004798	1.004858	1.004920	1.004980
73	1.004913	1.004965	1.005017	1.005082	1.005147	1.005212	1.005277	1.005345	1.005410
74	1.005304	1.005360	1.005416	1.005486	1.005556	1.005626	1.005696	1.005770	1.005840
75	1.005695	1.005755	1.005815	1.005890	1.005965	1.006040	1.006115	1.006195	..006270
76	1.006086	1.006150	1.006214	1.006294	1.006374	1.006454	1.006534	1.006620	1.006700
77	1.006477	1.006545	1.006613	1.006698	1.006783	1.006868	1.006953	1.007045	1.007130
78	1.006868	1.006940	1.007012	1.007102	1.007192	1.007282	1.007372	1.007470	1.007560
79	1.007259	1.007335	1.007411	1.007506	1.007601	1.007696	1.007791	1.007895	1.007990
80	1.007650	1.007730	1.007810	1.007910	1.008010	1.008110	1.008210	1.008320	1.008420
81	1.008058	1.008142	1.008226	1.008331	1.008437	1.008542	1.008647	1.008763	1.008869
82	1.008466	1.008554	1.008642	1.008752	1.008864	1.008974	1.009084	1.009206	1.009318
83	1.008874	1.008966	1.009058	1.009178	1.009291	1.009406	1.009521	1.009649	1.009767
84	1.009282	1.009378	1.009474	1.009594	1.009718	1.009838	1.009958	1.010092	1.010216
85	1.009690	1.009790	1.009890	1.010015	1.010145	1.010270	1.010395	1.010535	1.010665
86	1.010098	1.010202	1.010306	1.010436	1.010572	1.010702	1.010832	1.010978	1.011114
87	1.010506	1.010614	1.010722	1.010857	1.010999	1.011134	1.011269	1.011421	1.011563
88	1.010914	1.011026	1.011138	1.011278	1.011426	1.011566	1.011706	1.011864	1.012012
89	1.011322	1.011438	1.011554	1.011699	1.011853	1.011998	1.012143	1.012307	1.012461
90	1.011730	1.011850	1.011970	1.012120	1.012280	1.012430	1.012580	1.012750	1.012910
91	1.012155	1.012279	1.012404	1.012559	1.012725	1.012880	1.013035	1.013212	1.013378
92	1.012580	1.012708	1.012838	1.012998	1.013170	1.013330	1.013490	1.013674	1.013846
93	1.013005	1.013137	1.013272	1.013437	1.013615	1.013780	1.013945	1.014136	1.014314
94	1.013430	1.013566	1.013706	1.013876	1.014060	1.014230	1.014400	1.014598	1.014782
95	1.013855	1.013995	1.014140	1.014315	1.014505	1.014680	1.014855	1.015060	1.015250
96	1.014280	1.014424	1.014574	1.014754	1.014950	1.015130	1.015310	1.015522	1.015718
97	1.014705	1.014853	1.015008	1.015193	1.015395	1.015580	1.015765	1.015984	1.016186
98	1.015130	1.015282	1.015442	1.015632	1.015840	1.016030	1.016220	1.016446	1.016654
99	1.015555	1.015711	1.015876	1.016071	1.016285	1.016480	1.016675	1.016908	1.017122
100	1.015980	1.016140	1.016310	1.016510	1.016730	1.016930	1.017130	1.017370	1.017590
101	1.016422	1.016587	1.016762	1.016967	1.017193	1.017399	1.017644	1.017851	1.018077
102	1.016864	1.017034	1.017214	1.017424	1.017656	1.017868	1.018078	1.018332	1.018564
103	1.017306	1.017481	1.017666	1.017881	1.018119	1.018337	1.018552	1.018813	1.019051
104	1.017748	1.017928	1.018118	1.018338	1.018582	1.018806	1.019026	1.019294	1.019538
105	1.018190	1.018375	1.018570	1.018795	1.019045	1.019275	1.019500	1.019775	1.020025
106	1.018632	1.018822	1.019022	1.019252	1.019508	1.019744	1.019974	1.020256	1.020512
107	1.019074	1.019269	1.019470	1.019709	1.019971	1.020213	1.020448	1.020737	1.020999
108	1.019516	1.019716	1.019926	1.020166	1.020434	1.020682	1.020922	1.021218	1.021486
109	1.019958	1.020163	1.020378	1.020623	1.020897	1.021151	1.021396	1.021699	1.021973
110	1.020400	1.020610	1.020830	1.021080	1.021360	1.021620	1.021870	1.022180	1.022460
111	1.020860	1.021075	1.021300	1.021556	1.021842	1.022108	1.022363	1.022680	1.022967
112	1.021320	1.021540	1.021770	1.022032	1.022324	1.022596	1.022856	1.023180	1.023474
113	1.021780	1.022005	1.022240	1.022508	1.022806	1.023084	1.023349	1.023680	1.023981
114	1.022240	1.022470	1.022710	1.022984	1.023288	1.023572	1.023842	1.024180	1.024488
115	1.022700	1.022935	1.023180	1.023460	1.023770	1.024060	1.024335	1.024680	1.024995
116	1.023160	1.023400	1.023650	1.023936	1.024252	1.024548	1.024828	1.025180	1.025502
117	1.023620	1.023865	1.024120	1.024412	1.024734	1.025036	1.025321	1.025680	1.026009
118	1.024080	1.024330	1.024590	1.024888	1.025216	1.025524	1.025814	1.026180	1.026516
119	1.024540	1.024795	1.025060	1.025364	1.025698	1.026012	1.026307	1.026680	1.027023
120	1.025000	1.025260	1.025530	1.025840	1.026180	1.026500	1.026800	1.027180	1.027530
121	1.025478	1.025743	1.026019	1.026335	1.026681	1.027007	1.027313	1.027700	1.028057
122	1.025956	1.026226	1.026508	1.026830	1.027182	1.027514	1.027826	1.028220	1.028584
123	1.026434	1.026709	1.026997	1.027325	1.027683	1.028021	1.028339	1.028740	1.029111
124	1.026912	1.027192	1.027486	1.027820	1.028184	1.028528	1.028852	1.029260	1.029638
125	1.027390	1.027675	1.027975	1.028315	1.028685	1.029035	1.029365	1.029780	1.030165
126	1.027868	1.028158	1.028464	1.028810	1.029186	1.029542	1.029878	1.030300	1.030692
127	1.028346	1.028641	1.028953	1.029305	1.029687	1.030049	1.030391	1.030820	1.031219
128	1.028824	1.029124	1.029442	1.029800	1.030188	1.030556	1.030904	1.031340	1.031746
129	1.029302	1.029607	1.029931	1.030295	1.030689	1.031063	1.031417	1.031860	1.032273
130	1.029780	1.030090	1.030420	1.030790	1.031190	1.031570	1.031930	1.032380	1.032800

TABLE OF EXPANSION OF THE WEST VIRGINIA NATURAL OILS—Continued.

DEGREES OF GRAVITY.									Degrees of temperature. (F.)
37°.	38°.	39°.	40°.	41°.	42°.	43°.	44°.	45°.	
1.002508	1.002544	1.002580	1.002616	1.002652	1.002694	1.002736	1.002778	1.002820	66
1.002926	1.002968	1.003010	1.003052	1.003094	1.003143	1.003192	1.003241	1.003290	67
1.003344	1.003392	1.003440	1.003488	1.003536	1.003592	1.003648	1.003704	1.003760	68
1.003762	1.003816	1.003870	1.003924	1.003978	1.004041	1.004104	1.004167	1.004230	69
1.004180	1.004240	1.004300	1.004360	1.004420	1.004490	1.004560	1.004630	1.004700	70
1.004616	1.004682	1.004748	1.004814	1.004880	1.004957	1.005034	1.005112	1.005189	71
1.005052	1.005124	1.005196	1.005268	1.005340	1.005424	1.005508	1.005592	1.005678	72
1.005488	1.005566	1.005644	1.005722	1.005800	1.005891	1.005982	1.006076	1.006167	73
1.005924	1.006008	1.006092	1.006176	1.006260	1.006358	1.006456	1.006558	1.006656	74
1.006360	1.006450	1.006540	1.006630	1.006720	1.006825	1.006930	1.007040	1.007145	75
1.006796	1.006892	1.006988	1.007084	1.007180	1.007292	1.007404	1.007522	1.007634	76
1.007232	1.007334	1.007436	1.007538	1.007640	1.007759	1.007878	1.008004	1.008123	77
1.007668	1.007776	1.007884	1.007992	1.008100	1.008226	1.008352	1.008486	1.008612	78
1.008104	1.008218	1.008332	1.008446	1.008560	1.008693	1.008826	1.008968	1.009101	79
1.008540	1.008660	1.008780	1.008900	1.009020	1.009160	1.009300	1.009450	1.009590	80
1.008995	1.009121	1.009247	1.009373	1.009499	1.009646	1.009793	1.009951	1.010099	81
1.009450	1.009582	1.009714	1.009846	1.009978	1.010132	1.010286	1.010452	1.010608	82
1.009905	1.010043	1.010181	1.010319	1.010457	1.010618	1.010779	1.010953	1.011117	83
1.010360	1.010504	1.010648	1.010792	1.010936	1.011104	1.011272	1.011454	1.011626	84
1.010815	1.010965	1.011115	1.011265	1.011415	1.011590	1.011765	1.011955	1.012135	85
1.011270	1.011426	1.011582	1.011738	1.011894	1.012076	1.012258	1.012456	1.012644	86
1.011725	1.011887	1.012049	1.012211	1.012373	1.012562	1.012751	1.012957	1.013153	87
1.012180	1.012348	1.012516	1.012684	1.012852	1.013048	1.013244	1.013458	1.013662	88
1.012635	1.012809	1.012983	1.013157	1.013331	1.013534	1.013737	1.013959	1.014171	89
1.013090	1.013270	1.013450	1.013630	1.013810	1.014020	1.014230	1.014460	1.014680	90
1.013564	1.013750	1.013937	1.014123	1.014309	1.014526	1.014743	1.014981	1.015209	91
1.014038	1.014230	1.014424	1.014616	1.014808	1.015032	1.015256	1.015502	1.015738	92
1.014512	1.014710	1.014911	1.015109	1.015307	1.015538	1.015769	1.016023	1.016267	93
1.014986	1.015190	1.015398	1.015602	1.015806	1.016044	1.016282	1.016544	1.016796	94
1.015460	1.015670	1.015885	1.016095	1.016305	1.016550	1.016795	1.017065	1.017325	95
1.015934	1.016150	1.016372	1.016588	1.016804	1.017056	1.017308	1.017586	1.017854	96
1.016408	1.016630	1.016859	1.017081	1.017303	1.017562	1.017821	1.018107	1.018383	97
1.016882	1.017110	1.017346	1.017574	1.017802	1.018068	1.018334	1.018628	1.018912	98
1.017356	1.017590	1.017833	1.018067	1.018301	1.018574	1.018847	1.019149	1.019441	99
1.017830	1.018070	1.018320	1.018560	1.018800	1.019080	1.019360	1.019670	1.019970	100
1.018324	1.018570	1.018827	1.019073	1.019320	1.019607	1.019894	1.020212	1.020520	101
1.018818	1.019070	1.019334	1.019586	1.019840	1.020134	1.020428	1.020754	1.021070	102
1.019312	1.019570	1.019841	1.020099	1.020360	1.020661	1.020962	1.021296	1.021620	103
1.019806	1.020070	1.020348	1.020612	1.020880	1.021088	1.021496	1.021838	1.022170	104
1.020300	1.020570	1.020855	1.021125	1.021400	1.021715	1.022030	1.022380	1.022720	105
1.020794	1.021070	1.021362	1.021638	1.021920	1.022242	1.022564	1.022922	1.023270	106
1.021288	1.021570	1.021869	1.022151	1.022440	1.022769	1.023098	1.023464	1.023820	107
1.021782	1.022070	1.022376	1.022664	1.022960	1.023296	1.023632	1.024006	1.024370	108
1.022276	1.022570	1.022883	1.023177	1.023480	1.023823	1.024166	1.024548	1.024920	109
1.022770	1.023070	1.023390	1.023690	1.024000	1.024350	1.024700	1.025090	1.025470	110
1.023284	1.023590	1.023917	1.024224	1.024541	1.024899	1.025256	1.025654	1.026042	111
1.023798	1.024110	1.024444	1.024758	1.025082	1.025448	1.025812	1.026218	1.026614	112
1.024312	1.024630	1.024971	1.025292	1.025623	1.025997	1.026368	1.026782	1.027186	113
1.024826	1.025150	1.025498	1.025826	1.026164	1.026546	1.026924	1.027346	1.027758	114
1.025340	1.025670	1.026025	1.026360	1.026705	1.027095	1.027480	1.027910	1.028330	115
1.025854	1.026190	1.026552	1.026894	1.027246	1.027644	1.028036	1.028474	1.028902	116
1.026368	1.026710	1.027079	1.027428	1.027787	1.028193	1.028592	1.029038	1.029474	117
1.026882	1.027230	1.027606	1.027962	1.028328	1.028742	1.029148	1.029602	1.030046	118
1.027396	1.027750	1.028133	1.028496	1.028869	1.029291	1.029704	1.030166	1.030618	119
1.027910	1.028270	1.028660	1.029030	1.029410	1.029840	1.030260	1.030730	1.031190	120
1.028444	1.028811	1.029208	1.029585	1.029973	1.030411	1.030839	1.031317	1.031785	121
1.028978	1.029352	1.029756	1.030140	1.030536	1.030982	1.031418	1.031904	1.032380	122
1.029512	1.029893	1.030304	1.030695	1.031099	1.031553	1.031997	1.032491	1.032975	123
1.030046	1.030434	1.030852	1.031250	1.031662	1.032124	1.032576	1.033078	1.033570	124
1.030580	1.030975	1.031400	1.031805	1.032225	1.032695	1.033155	1.033665	1.034165	125
1.031114	1.031516	1.031948	1.032360	1.032788	1.033266	1.033734	1.034252	1.034760	126
1.031648	1.032057	1.032496	1.032915	1.033351	1.033837	1.034313	1.034839	1.035355	127
1.032182	1.032598	1.033044	1.033470	1.033914	1.034408	1.034892	1.035426	1.035950	128
1.032716	1.033139	1.033592	1.034025	1.034477	1.034979	1.035471	1.036013	1.036545	129
1.033250	1.033680	1.034140	1.034580	1.035040	1.035550	1.036050	1.036600	1.037140	130

TABLES FOR THE RAPID AND EXACT COMPUTATION OF THE NUMBER OF GALLONS CONTAINED IN ANY GIVEN WEIGHT OF OIL OR OTHER LIQUID LIGHTER THAN WATER, WITHOUT MEASURING OR GAUGING.

ARRANGED WITH SPECIAL REFERENCE TO THE WANTS OF THE PETROLEUM TRADE.

By S. A. Lattimore, A. M., *Professor of Chemistry in the University of Rochester, New York.*

Instructions for the use of the tables.—Ascertain the net weight of the oil or other fluid by the balance. The gravity is to be next accurately ascertained by means of a correct hydrometer, the temperature of the fluid being 60° F. and the line of the scale just below the surface being taken. Turn to the page on which that gravity is given. In the first column find the number of pounds. Opposite this number, in the column for the proper gravity, will be found the corresponding number of gallons, tenths and hundredths. If the exact number of pounds does not occur, take the nearest smaller number, then the number next less than the remainder, and so on, until the sum of these several numbers is the exact number of pounds required.

Example.

In 2,384 pounds of oil of 45° B., how many gallons?

	Gallons.
2,000 pounds	300.08
300 pounds	45.01
80 pounds	12.00
4 pounds	0.60
2,384 pounds	357.69

An additional series of tables is given embracing the more common gravities of petroleum products and the range of the number of gallons ordinarily contained in a single cask. Find the page for the required gravity, and opposite the net weight will be found the exact number of gallons contained in the cask.

DEGREES OF BAUMÉ'S HYDROMETER.

Pounds.	15°.	16°.	17°.	18°.	19°.	20°.	21°.	22°.	23°.	24°.	25°.	26°.	27°.	28°.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1	0.12	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.14	0.14
2	0.25	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.26	0.27	0.27	0.27	0.27
3	0.37	0.38	0.38	0.38	0.38	0.39	0.39	0.39	0.39	0.40	0.40	0.40	0.40	0.41
4	0.50	0.50	0.50	0.51	0.51	0.52	0.52	0.52	0.53	0.53	0.53	0.54	0.54	0.54
5	0.62	0.63	0.63	0.63	0.64	0.64	0.65	0.65	0.66	0.66	0.66	0.67	0.67	0.68
6	0.75	0.76	0.76	0.76	0.77	0.77	0.78	0.78	0.79	0.79	0.80	0.80	0.81	0.81
7	0.87	0.88	0.88	0.89	0.89	0.90	0.91	0.91	0.92	0.92	0.93	0.94	0.94	0.95
8	1.00	1.00	1.01	1.02	1.02	1.03	1.04	1.04	1.05	1.06	1.06	1.07	1.08	1.08
9	1.12	1.13	1.13	1.14	1.15	1.16	1.17	1.17	1.18	1.20	1.20	1.20	1.21	1.22
10	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.30	1.31	1.32	1.33	1.34	1.35	1.35
20	2.49	2.50	2.52	2.54	2.56	2.57	2.58	2.61	2.62	2.64	2.66	2.68	2.69	2.71
30	3.73	3.76	3.78	3.81	3.83	3.86	3.88	3.91	3.94	3.96	3.99	4.01	4.04	4.06
40	4.97	5.01	5.04	5.08	5.11	5.15	5.18	5.21	5.25	5.28	5.31	5.35	5.38	5.42
50	6.22	6.26	6.30	6.34	6.39	6.43	6.47	6.52	6.56	6.60	6.64	6.69	6.73	6.77
60	7.46	7.51	7.56	7.61	7.67	7.72	7.77	7.82	7.87	7.92	7.97	8.03	8.08	8.13
70	8.70	8.76	8.82	8.88	8.94	9.00	9.06	9.12	9.18	9.24	9.30	9.36	9.42	9.48
80	9.95	10.01	10.08	10.15	10.22	10.29	10.36	10.43	10.49	10.56	10.63	10.70	10.77	10.84
90	11.19	11.27	11.34	11.42	11.50	11.58	11.65	11.73	11.81	11.98	11.96	12.04	12.12	12.19
100	12.43	12.52	12.61	12.69	12.78	12.86	12.95	13.03	13.12	13.21	13.29	13.38	13.46	13.55
200	24.87	25.04	25.21	25.38	25.55	25.72	25.84	26.07	26.24	26.41	26.57	26.75	26.92	27.10
300	37.30	37.55	37.81	38.07	38.33	38.58	38.84	39.10	39.36	39.62	39.86	40.13	40.38	40.64
400	49.73	50.07	50.42	50.76	51.11	51.45	51.79	52.13	52.47	52.82	53.15	53.50	53.85	54.19
500	62.16	62.59	63.02	63.45	63.88	64.31	64.74	65.16	65.59	66.03	66.45	66.88	67.30	67.74
1,000	124.32	125.18	126.05	126.90	127.76	128.61	129.47	130.33	131.18	132.05	132.87	133.76	134.61	135.48
2,000	248.65	250.36	252.09	253.80	255.53	257.22	258.94	260.66	262.37	264.10	265.73	267.52	269.22	270.96
3,000	372.97	375.54	378.13	380.69	383.29	385.84	388.42	390.99	393.55	396.15	398.60	401.28	403.83	406.43
4,000	497.29	500.71	504.18	507.59	511.05	514.45	517.89	521.31	524.73	528.20	531.47	535.03	538.45	541.91
5,000	621.61	625.89	630.23	634.49	638.81	643.06	647.36	651.64	655.92	660.25	664.34	668.79	673.06	677.39
10,000	1,243.22	1,251.78	1,260.46	1,268.99	1,277.63	1,286.12	1,294.72	1,303.29	1,311.84	1,320.50	1,328.67	1,337.58	1,346.11	1,354.78
20,000	2,486.45	2,503.57	2,520.92	2,537.97	2,555.26	2,572.24	2,589.43	2,606.58	2,623.67	2,641.00	2,657.35	2,675.15	2,692.22	2,709.56

DEGREES OF BAUMÉ'S HYDROMETER—Continued.

Pounds.	29°.	30°.	31°.	32°.	33°.	34°.	35°.	36°.	37°.	38°.	39°.	40°.	41°.	42°.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15
2	0.27	0.27	0.28	0.28	0.28	0.28	0.28	0.28	0.29	0.29	0.29	0.29	0.29	0.29
3	0.41	0.41	0.41	0.42	0.42	0.42	0.43	0.43	0.43	0.43	0.43	0.44	0.44	0.44
4	0.55	0.55	0.56	0.56	0.56	0.56	0.57	0.57	0.57	0.58	0.58	0.58	0.59	0.59
5	0.68	0.69	0.69	0.69	0.70	0.70	0.71	0.71	0.72	0.72	0.72	0.73	0.73	0.74
6	0.82	0.82	0.83	0.83	0.84	0.84	0.85	0.85	0.86	0.86	0.87	0.88	0.88	0.89
7	0.95	0.96	0.97	0.97	0.98	0.98	0.99	1.00	1.00	1.01	1.01	1.02	1.03	1.03
8	1.09	1.10	1.10	1.11	1.12	1.13	1.13	1.14	1.15	1.15	1.16	1.17	1.17	1.18
9	1.23	1.24	1.24	1.25	1.26	1.27	1.27	1.28	1.29	1.30	1.30	1.30	1.32	1.33
10	1.36	1.37	1.38	1.39	1.40	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.47
20	2.73	2.74	2.76	2.78	2.80	2.81	2.83	2.85	2.87	2.88	2.90	2.92	2.93	2.95
30	4.09	4.12	4.14	4.17	4.19	4.22	4.25	4.27	4.30	4.32	4.35	4.37	4.40	4.42
40	5.45	5.49	5.52	5.56	5.59	5.63	5.66	5.69	5.73	5.76	5.80	5.83	5.86	5.90
50	6.82	6.86	6.90	6.94	6.99	7.03	7.07	7.12	7.16	7.20	7.24	7.29	7.33	7.37
60	8.18	8.23	8.28	8.33	8.39	8.44	8.49	8.54	8.60	8.64	8.69	8.75	8.80	8.85
70	9.53	9.60	9.66	9.72	9.78	9.84	9.91	9.96	10.03	10.08	10.14	10.20	10.26	10.32
80	10.91	10.97	11.04	11.11	11.18	11.25	11.33	11.39	11.46	11.52	11.59	11.66	11.73	11.80
90	12.27	12.35	12.42	12.50	12.58	12.66	12.73	12.81	12.89	12.96	13.04	13.12	13.20	13.27
100	13.63	13.72	13.80	13.89	13.98	14.06	14.15	14.23	14.33	14.40	14.49	14.58	14.66	14.75
200	27.27	27.44	27.61	27.78	27.95	28.12	28.30	28.47	28.65	28.81	28.98	29.16	29.32	29.50
300	40.90	41.15	41.42	41.67	41.93	42.19	42.45	42.70	42.98	43.21	43.46	43.73	43.98	44.24
400	54.53	54.87	55.22	55.56	55.91	56.25	56.60	56.93	57.30	57.62	57.95	58.31	58.65	58.99
500	68.16	68.59	69.02	69.45	69.88	70.31	70.74	71.17	71.63	72.02	72.44	72.89	72.31	73.74
1,000	136.33	137.18	138.05	138.91	139.77	140.62	141.48	142.34	143.26	144.04	144.88	145.77	146.61	147.48
2,000	272.65	274.36	276.10	277.81	279.54	281.24	282.97	284.67	286.51	288.09	289.76	291.55	293.23	294.96
3,000	408.97	411.54	414.14	416.71	419.30	421.87	424.44	427.02	429.78	432.12	434.64	437.31	439.84	442.44
4,000	545.30	548.72	552.19	555.62	559.07	562.49	565.92	569.36	573.04	576.16	579.52	583.09	586.46	589.92
5,000	681.63	685.90	690.24	694.52	698.84	703.11	707.41	711.68	716.29	720.24	724.41	728.86	733.07	737.40
10,000	1,363.25	1,371.81	1,380.49	1,389.05	1,397.68	1,406.21	1,414.83	1,423.36	1,432.58	1,440.47	1,448.81	1,457.73	1,466.15	1,474.80
20,000	2,726.50	2,743.63	2,760.98	2,778.10	2,795.36	2,812.42	2,829.65	2,846.73	2,865.16	2,880.93	2,897.63	2,915.45	2,932.29	2,949.59

Pounds.	43°.	44°.	45°.	46°.	47°.	48°.	49°.	50°.	51°.	52°.	53°.	54°.	55°.	56°.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16
2	0.30	0.30	0.30	0.30	0.30	0.31	0.31	0.31	0.31	0.31	0.31	0.32	0.32	0.32
3	0.45	0.45	0.45	0.45	0.46	0.46	0.46	0.46	0.47	0.47	0.47	0.47	0.48	0.48
4	0.59	0.60	0.60	0.60	0.61	0.61	0.61	0.62	0.62	0.62	0.63	0.63	0.64	0.64
5	0.74	0.75	0.75	0.76	0.76	0.76	0.77	0.77	0.78	0.78	0.79	0.79	0.79	0.80
6	0.89	0.89	0.90	0.91	0.91	0.92	0.92	0.93	0.93	0.94	0.94	0.95	0.95	0.96
7	1.04	1.04	1.05	1.06	1.06	1.07	1.07	1.08	1.09	1.09	1.10	1.10	1.11	1.12
8	1.19	1.19	1.20	1.21	1.21	1.22	1.23	1.24	1.24	1.25	1.26	1.26	1.27	1.28
9	1.34	1.34	1.35	1.36	1.37	1.37	1.38	1.39	1.40	1.40	1.41	1.42	1.43	1.44
10	1.48	1.49	1.50	1.51	1.52	1.53	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.59
20	2.97	2.98	3.00	3.02	3.04	3.05	3.07	3.09	3.10	3.12	3.14	3.16	3.17	3.19
30	4.45	4.47	4.50	4.53	4.55	4.58	4.60	4.63	4.66	4.68	4.71	4.73	4.76	4.78
40	5.93	5.96	6.00	6.04	6.07	6.11	6.14	6.17	6.21	6.24	6.28	6.31	6.35	6.38
50	7.41	7.45	7.50	7.55	7.59	7.63	7.67	7.72	7.76	7.80	7.85	7.89	7.93	7.97
60	8.90	8.94	9.00	9.05	9.11	9.16	9.21	9.26	9.31	9.36	9.41	9.47	9.52	9.57
70	10.38	10.43	10.50	10.56	10.62	10.68	10.74	10.80	10.86	10.92	10.98	11.04	11.10	11.16
80	11.87	11.92	12.00	12.07	12.14	12.21	12.28	12.35	12.42	12.48	12.55	12.62	12.69	12.76
90	13.35	13.41	13.50	13.59	13.66	13.74	13.81	13.89	13.97	14.04	14.12	14.20	14.28	14.35
100	14.83	14.91	15.00	15.09	15.18	15.26	15.35	15.43	15.52	15.61	15.69	15.78	15.86	15.95
200	29.67	29.81	30.00	30.18	30.36	30.52	30.70	30.87	31.04	31.21	31.38	31.56	31.73	31.90
300	44.50	44.72	45.01	45.27	45.53	45.79	46.04	46.30	46.56	46.82	47.07	47.33	47.59	47.85
400	59.34	59.62	60.02	60.36	60.71	61.05	61.39	61.74	62.08	62.42	62.76	63.11	63.45	63.80
500	74.17	74.53	75.02	75.45	75.88	76.31	76.74	77.17	77.60	78.03	78.45	78.89	79.31	79.75
1,000	148.34	149.05	150.04	150.91	151.77	152.62	153.48	154.34	155.20	156.05	156.91	157.77	158.63	159.49
2,000	296.67	298.11	300.08	301.82	303.50	305.24	306.95	308.69	310.40	312.10	313.81	315.55	317.25	318.98
3,000	445.02	447.16	450.13	452.73	455.30	457.85	460.43	463.03	465.60	468.15	470.72	473.32	475.88	478.47
4,000	593.35	596.22	600.17	603.64	607.07	610.47	613.91	617.38	620.80	624.20	627.63	631.09	634.51	637.96
5,000	741.69	745.27	750.21	754.55	758.84	763.09	767.38	771.72	776.01	780.25	784.54	788.87	793.13	797.45
10,000	1,483.37	1,490.53	1,500.42	1,509.09	1,517.68	1,526.18	1,534.75	1,543.45	1,552.02	1,560.50	1,569.07	1,577.74	1,586.27	1,594.90
20,000	2,966.74	2,981.07	3,000.84	3,018.18	3,035.36	3,052.36	3,069.51	3,086.90	3,104.05	3,121.00	3,138.14	3,155.47	3,172.53	3,189.79

DEGREES OF BAUMÉ'S HYDROMETER—Continued.

Pounds.	57°.	58°.	59°.	60°.	61°.	62°.	63°.	64°.	65°.	70°.	75°.	80°.	85°.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18
2	0.32	0.32	0.32	0.32	0.33	0.33	0.33	0.33	0.33	0.34	0.35	0.36	0.37
3	0.48	0.48	0.49	0.49	0.49	0.49	0.50	0.50	0.50	0.51	0.53	0.54	0.55
4	0.64	0.65	0.65	0.65	0.66	0.66	0.66	0.67	0.67	0.69	0.70	0.72	0.74
5	0.80	0.81	0.81	0.82	0.82	0.82	0.83	0.83	0.84	0.86	0.88	0.99	0.92
6	0.96	0.97	0.97	0.98	0.98	0.99	1.00	1.00	1.00	1.03	1.06	1.08	1.11
7	1.12	1.13	1.13	1.14	1.15	1.15	1.16	1.16	1.17	1.20	1.23	1.26	1.29
8	1.28	1.29	1.30	1.30	1.31	1.31	1.32	1.33	1.34	1.37	1.41	1.44	1.48
9	1.44	1.45	1.46	1.47	1.47	1.48	1.49	1.50	1.50	1.54	1.58	1.62	1.66
10	1.60	1.61	1.62	1.63	1.64	1.65	1.65	1.66	1.67	1.72	1.76	1.80	1.84
20	3.21	3.22	3.24	3.24	3.28	3.29	3.31	3.33	3.34	3.43	3.52	3.60	3.69
30	4.81	4.84	4.86	4.89	4.91	4.94	4.96	4.99	5.02	5.14	5.28	5.40	5.53
40	6.41	6.45	6.48	6.52	6.55	6.59	6.62	6.65	6.69	6.86	7.03	7.20	7.37
50	8.02	8.06	8.10	8.15	8.19	8.23	8.27	8.32	8.36	8.57	8.79	9.00	9.22
60	9.62	9.67	9.72	9.77	9.83	9.88	9 93	9.99	10.03	10.29	10.55	10.80	11.06
70	11.22	11.28	11.34	11.40	11.46	11.53	11.58	11.64	11.69	12.00	12.31	12.60	12.90
80	12.83	12.90	12.96	13.03	13.10	13.16	13.24	13.31	13.38	13.72	14.07	14.41	14.75
90	14.43	14.51	14.58	14.66	14.74	14.82	14.89	14.97	15.05	15.43	15.83	16.21	16.59
100	16.03	16.12	16.21	16.29	16.38	16.47	16.55	16.64	16.72	17.15	17.59	18.01	18.44
200	32.07	32.24	32.41	32.58	32.76	32.93	33.10	33.27	33.44	34.30	35.17	36.01	36.87
300	48.10	48.36	48.61	48.87	49.13	49.40	49.65	49.90	50.16	51.44	52.76	54.02	55.31
400	64.14	64.48	64.82	65.16	65.51	65.86	66.20	66.54	66.88	68.59	70.34	72.03	73.74
500	80.17	80.60	81.03	81.46	81.89	82.33	82.75	83.17	83.60	85.74	87.93	90.04	92.18
1,000	160.34	161.21	162.05	162.91	163.78	164.66	165.49	166.35	167.20	171.48	175.86	180.07	184.36
2,000	320.69	322.41	324.11	323.82	327.56	329.31	330.99	332.69	334.40	342.95	351.72	360.14	368.71
3,000	481.03	483.60	486.16	488.73	491.34	493.97	496.48	499.03	510.60	514.43	527.58	540.21	553.06
4,000	641.37	644.82	648.21	651.64	655.11	658.62	661.98	665.38	668.81	685.91	703.44	720.28	737.42
5,000	801.72	806.02	810.27	814.56	818.89	823.28	827.47	831.73	836.01	857.38	879.30	900.35	921.77
10,000	1,603.44	1,612.05	1,620.54	1,629.12	1,637.79	1,646.55	1,654.94	1,663.45	1,672.02	1,714.77	1,758.59	1,800.70	1,843.55
20,000	3,206.87	3,224.09	3,241.07	3,238.24	3,275.57	3,293.10	3,309.88	3,326.90	3,344.03	3,429.53	3,517.18	3,601.40	3,687.11

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL.

15° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
288	35.8	318	39.5	348	43.3	378	47.0	408	50.7
289	35.9	319	39.7	349	43.4	379	47.1	409	50.9
290	36.1	320	39.8	350	43.5	380	47.3	410	51.0
291	36.2	321	39.9	351	43.6	381	47.4	411	51.1
292	36.3	322	40.0	352	43.8	382	47.5	412	51.2
293	36.4	323	40.2	353	43.9	383	47.6	413	51.3
294	36.6	324	40.3	354	44.0	384	47.8	414	51.5
295	36.7	325	40.4	355	44.1	385	47.9	415	51.6
296	36.8	326	40.5	356	44.3	386	48.0	416	51.7
297	36.9	327	40.7	357	44.4	387	48.1	417	51.8
298	37.1	328	40.8	358	44.5	388	48.3	418	52.0
299	37.2	329	40.9	359	44.6	389	48.4	419	52.1
300	37.3	330	41.0	360	44.8	390	48.5	420	52.2
301	37.4	331	41.2	361	44.9	391	48.6	421	52.3
302	37.6	332	41.3	362	45.0	392	48.7	422	52.5
303	37.7	333	41.4	363	45.1	393	48.9	423	52.6
304	37.8	334	41.5	364	45.3	394	49.0	424	52.7
305	37.9	335	41.7	365	45.4	395	49.1	425	52.8
306	38.1	336	41.8	366	45.5	396	49.2	426	53.0
307	38.2	337	41.9	367	45.6	397	49.4	427	53.1
308	38.3	338	42.0	368	45.8	398	49.5	428	53.2
309	38.4	339	42.2	369	45.9	399	49.6	429	53.3
310	38.5	340	42.3	370	46.0	400	49.7	430	53.5
311	38.7	341	42.4	371	46.1	401	49.9	431	53.6
312	38.8	342	42.5	372	46.3	402	50.0	432	53.7
313	38.9	343	42.6	373	46.4	403	50.1	433	53.8
314	39.0	344	42.8	374	46.5	404	50.2	434	53.9
315	39.2	345	42.9	375	46.6	405	50.4	435	54.0
316	39.3	346	43.0	376	46.8	406	50.5	436	54.2
317	39.4	347	43.1	377	46.9	407	50.6	437	54.3

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

20° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
280	36.0	310	39.9	340	43.7	370	47.6	400	51.5
281	36.1	311	40.0	341	43.9	371	47.7	401	51.6
282	36.3	312	40.1	342	44.0	372	47.8	402	51.7
283	36.4	313	40.3	343	44.1	373	48.0	403	51.8
284	36.5	314	40.4	344	44.3	374	48.1	404	52.0
285	36.7	315	40.5	345	44.4	375	48.2	405	52.1
286	36.8	316	40.6	346	44.5	376	48.4	406	52.2
287	36.9	317	40.8	347	44.6	377	48.5	407	52.4
288	37.0	318	40.9	348	44.8	378	48.6	408	52.5
289	37.2	319	41.0	349	44.9	379	48.7	409	52.6
290	37.3	320	41.2	350	45.0	380	48.9	410	52.7
291	37.4	321	41.3	351	45.1	381	49.0	411	52.9
292	37.6	322	41.4	352	45.3	382	49.1	412	53.0
293	37.7	323	41.5	353	45.4	383	49.3	413	53.1
294	37.8	324	41.7	354	45.5	384	49.4	414	53.3
295	37.9	325	41.8	355	45.7	385	49.5	415	53.4
296	38.1	326	41.9	356	45.8	386	49.6	416	53.5
297	38.2	327	42.1	357	45.9	387	49.8	417	53.6
298	38.3	328	42.2	358	46.0	388	49.9	418	53.8
299	38.5	329	42.3	359	46.2	389	50.0	419	53.9
300	38.6	330	42.4	360	46.3	390	50.2	420	54.0
301	38.7	331	42.6	361	46.4	391	50.3	421	54.2
302	38.8	332	42.7	362	46.6	392	50.4	422	54.3
303	39.0	333	42.8	363	46.7	393	50.6	423	54.4
304	39.1	334	43.0	364	46.8	394	50.7	424	54.5
305	39.2	335	43.1	365	46.9	395	50.8	425	54.7
306	39.4	336	43.2	366	47.1	396	50.9	426	54.8
307	39.5	337	43.3	367	47.2	397	51.1	427	54.9
308	39.6	338	43.5	368	47.3	398	51.2	428	55.1
309	39.7	339	43.6	369	47.5	399	51.3	429	55.2

21° GRAVITY.

278	35.9	308	39.9	338	43.8	368	47.7	398	51.5
279	36.1	309	40.0	339	43.9	369	47.8	399	51.7
280	36.2	310	40.1	340	44.0	370	47.9	400	51.8
281	36.3	311	40.3	341	44.2	371	48.0	401	51.9
282	36.5	312	40.4	342	44.3	372	48.2	402	52.1
283	36.6	313	40.5	343	44.4	373	48.3	403	52.2
284	36.7	314	40.7	344	44.5	374	48.4	404	52.3
285	36.9	315	40.8	345	44.7	375	48.6	405	52.4
286	37.0	316	40.9	346	44.8	376	48.7	406	52.6
287	37.1	317	41.1	347	44.9	377	48.8	407	52.7
288	37.2	318	41.2	348	45.1	378	48.9	408	52.8
289	37.4	319	41.3	349	45.2	379	49.1	409	53.0
290	37.5	320	41.4	350	45.3	380	49.2	410	53.1
291	37.6	321	41.6	351	45.4	381	49.3	411	53.2
292	37.8	322	41.7	352	45.6	382	49.5	412	53.4
293	37.9	323	41.8	353	45.7	383	49.6	413	53.5
294	38.0	324	41.9	354	45.8	384	49.7	414	53.6
295	38.1	325	42.1	355	46.0	385	49.9	415	53.7
296	38.3	326	42.2	356	46.1	386	50.0	416	53.9
297	38.4	327	42.3	357	46.2	387	50.1	417	54.0
298	38.5	328	42.5	358	46.4	388	50.2	418	54.1
299	38.7	329	42.6	359	46.5	389	50.4	419	54.3
300	38.8	330	42.7	360	46.6	390	50.5	420	54.4
301	39.0	331	42.9	361	46.7	391	50.6	421	54.5
302	39.1	332	43.0	362	46.9	392	50.8	422	54.6
303	39.2	333	43.1	363	47.0	393	50.9	423	54.8
304	39.4	334	43.2	364	47.1	394	51.0	424	54.9
305	39.5	335	43.4	365	47.3	395	51.1	425	55.0
306	39.6	336	43.5	366	47.4	396	51.3	426	55.2
307	39.8	337	43.6	367	47.5	397	51.4	427	55.3

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

22° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
275	35.8	305	39.8	335	43.7	365	47.6	395	51.5
276	36.0	306	39.9	336	43.8	366	47.7	396	51.6
277	36.1	307	40.0	337	43.9	367	47.8	397	51.7
278	36.2	308	40.1	338	44.1	368	48.0	398	51.9
279	36.4	309	40.3	339	44.2	369	48.1	399	52.0
280	36.5	310	40.4	340	44.3	370	48.2	400	52.1
281	36.6	311	40.5	341	44.4	371	48.4	401	52.3
282	36.8	312	40.7	342	44.6	372	48.5	402	52.4
283	36.9	313	40.8	343	44.7	373	48.6	403	52.5
284	37.0	314	40.9	344	44.8	374	48.7	404	52.7
285	37.2	315	41.1	345	45.0	375	48.9	405	52.8
286	37.3	316	41.2	346	45.1	376	49.0	406	52.9
287	37.4	317	41.3	347	45.2	377	49.1	407	53.0
288	37.5	318	41.4	348	45.4	378	49.3	408	53.2
289	37.7	319	41.6	349	45.5	379	49.4	409	53.3
290	37.8	320	41.7	350	45.6	380	49.5	410	53.4
291	37.9	321	41.8	351	45.8	381	49.7	411	53.6
292	38.1	322	42.0	352	45.9	382	49.8	412	53.7
293	38.2	323	42.1	353	46.0	383	49.9	413	53.8
294	38.3	324	42.2	354	46.1	384	50.1	414	54.0
295	38.5	325	42.4	355	46.3	385	50.2	415	54.1
296	38.6	326	42.5	356	46.4	386	50.3	416	54.2
297	38.7	327	42.6	357	46.5	387	50.4	417	54.3
298	38.8	328	42.8	358	46.7	388	50.6	418	54.5
299	39.0	329	42.9	359	46.8	389	50.7	419	54.6
300	39.1	330	43.0	360	46.9	390	50.8	420	54.7
301	39.2	331	43.1	361	47.1	391	51.0	421	54.9
302	39.4	332	43.3	362	47.2	392	51.1	422	55.0
303	39.5	333	43.4	363	47.3	393	51.2	423	55.1
304	39.6	334	43.5	364	47.4	394	51.4	424	55.3

23° GRAVITY.

274	36.0	304	39.9	334	43.8	364	47.8	394	51.7
275	36.1	305	40.0	335	44.0	365	47.9	395	51.8
276	36.2	306	40.2	336	44.1	366	48.0	396	52.0
277	36.3	307	40.3	337	44.2	367	48.2	397	52.1
278	36.5	308	40.4	338	44.4	368	48.3	398	52.2
279	36.6	309	40.5	339	44.5	369	48.4	399	52.4
280	36.7	310	40.7	340	44.6	370	48.5	400	52.5
281	36.9	311	40.8	341	44.7	371	48.7	401	52.6
282	37.0	312	40.9	342	44.9	372	48.8	402	52.7
283	37.1	313	41.1	343	45.0	373	48.9	403	52.9
284	37.3	314	41.2	344	45.1	374	49.1	404	53.0
285	37.4	315	41.3	345	45.3	375	49.2	405	53.1
286	37.5	316	41.5	346	45.4	376	49.3	406	53.3
287	37.7	317	41.6	347	45.5	377	49.5	407	53.4
288	37.8	318	41.7	348	45.7	378	49.6	408	53.5
289	37.9	319	41.9	349	45.8	379	49.7	409	53.7
290	38.1	320	42.0	350	45.9	380	49.9	410	53.8
291	38.2	321	42.1	351	46.1	381	50.0	411	53.9
292	38.3	322	42.2	352	46.2	382	50.1	412	54.1
293	38.4	323	42.4	353	46.3	383	50.2	413	54.2
294	38.6	324	42.5	354	46.5	384	50.4	414	54.3
295	38.7	325	42.6	355	46.6	385	50.5	415	54.4
296	38.8	326	42.8	356	46.7	386	50.6	416	54.6
297	39.0	327	42.9	357	46.8	387	50.8	417	54.7
298	39.1	328	43.0	358	47.0	388	50.9	418	54.8
299	39.2	329	43.2	359	47.1	389	51.0	419	55.0
300	39.4	330	43.3	360	47.2	390	51.2	420	55.1
301	39.5	331	43.4	361	47.4	391	51.3	421	55.2
302	39.6	332	43.6	362	47.5	392	51.4	422	55.4
303	39.8	333	43.7	363	47.6	393	51.6	423	55.5

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

24° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
272	35.9	302	39.9	332	43.8	362	47.8	392	51.8
273	36.1	303	40.0	333	44.0	363	47.9	393	51.9
274	36.2	304	40.2	334	44.1	364	48.1	394	52.0
275	36.3	305	40.3	335	44.2	365	48.2	395	52.2
276	36.4	306	40.4	336	44.4	366	48.3	396	52.3
277	36.6	307	40.5	337	44.5	367	48.5	397	52.4
278	36.7	308	40.7	338	44.6	368	48.6	398	52.6
279	36.9	309	40.8	339	44.8	369	48.7	399	52.7
280	37.0	310	40.9	340	44.9	370	48.9	400	52.8
281	37.1	311	41.1	341	45.0	371	49.0	401	53.0
282	37.2	312	41.2	342	45.2	372	49.1	402	53.1
283	37.4	313	41.3	343	45.3	373	49.3	403	53.2
284	37.5	314	41.5	344	45.4	374	49.4	404	53.4
285	37.6	315	41.6	345	45.6	375	49.5	405	53.5
286	37.8	316	41.7	346	45.7	376	49.7	406	53.6
287	37.9	317	41.9	347	45.8	377	49.8	407	53.7
288	38.0	318	42.0	348	46.0	378	49.9	408	53.9
289	38.2	319	42.1	349	46.1	379	50.1	409	54.0
290	38.3	320	42.3	350	46.2	380	50.2	410	54.1
291	38.4	321	42.4	351	46.4	381	50.3	411	54.3
292	38.6	322	42.5	352	46.5	382	50.4	412	54.4
293	38.7	323	42.7	353	46.6	383	50.6	413	54.5
294	38.8	324	42.8	354	46.8	384	50.7	414	54.7
295	39.0	325	42.9	355	46.9	385	50.8	415	54.8
296	39.1	326	43.1	356	47.0	386	51.0	416	54.9
297	39.2	327	43.2	357	47.1	387	51.1	417	55.1
298	39.4	328	43.3	358	47.3	388	51.2	418	55.2
299	39.5	329	43.5	359	47.4	389	51.4	419	55.3
300	39.6	330	43.6	360	47.5	390	51.5	420	55.5
301	39.8	331	43.7	361	47.7	391	51.6	421	55.6

25° GRAVITY.

271	36.0	301	40.0	331	44.0	361	48.0	391	52.0
272	36.1	302	40.1	332	44.1	362	48.1	392	52.1
273	36.3	303	40.3	333	44.3	363	48.2	393	52.2
274	36.4	304	40.4	334	44.4	364	48.4	394	52.4
275	36.5	305	40.5	335	44.5	365	48.5	395	52.5
276	36.7	306	40.7	336	44.7	366	48.6	396	52.6
277	36.8	307	40.8	337	44.8	367	48.8	397	52.8
278	36.9	308	40.9	338	44.9	368	48.9	398	52.9
279	37.1	309	41.1	339	45.1	369	49.0	399	53.0
280	37.2	310	41.2	340	45.2	370	49.2	400	53.2
281	37.3	311	41.3	341	45.3	371	49.3	401	53.3
282	37.5	312	41.5	342	45.4	372	49.4	402	53.4
283	37.6	313	41.6	343	45.6	373	49.6	403	53.6
284	37.7	314	41.7	344	45.7	374	49.7	404	53.7
285	37.9	315	41.9	345	45.8	375	49.8	405	53.8
286	38.0	316	42.0	346	46.0	376	50.0	406	54.0
287	38.1	317	42.1	347	46.1	377	50.1	407	54.1
288	38.3	318	42.3	348	46.2	378	50.2	408	54.2
289	38.4	319	42.4	349	46.4	379	50.4	409	54.4
290	38.5	320	42.5	350	46.5	380	50.5	410	54.5
291	38.7	321	42.7	351	46.6	381	50.6	411	54.6
292	38.8	322	42.8	352	46.8	382	50.8	412	54.8
293	38.9	323	42.9	353	46.9	383	50.9	413	54.9
294	39.1	324	43.1	354	47.0	384	51.0	414	55.0
295	39.2	325	43.2	355	47.2	385	51.2	415	55.1
296	39.3	326	43.3	356	47.3	386	51.3	416	55.3
297	39.5	327	43.5	357	47.4	387	51.4	417	55.4
298	39.6	328	43.6	358	47.6	388	51.6	418	55.5
299	39.7	329	43.7	359	47.7	389	51.7	419	55.7
300	39.9	330	43.9	360	47.8	390	51.8	420	55.8

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

26° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
269	36.0	299	40.0	329	44.0	359	48.0	389	52.0
270	36.1	300	40.1	330	44.1	360	48.2	390	52.2
271	36.2	301	40.3	331	44.3	361	48.3	391	52.3
272	36.4	302	40.4	332	44.4	362	48.4	392	52.4
273	36.5	303	40.5	333	44.5	363	48.6	393	52.6
274	36.7	304	40.7	334	44.7	364	48.7	394	52.7
275	36.8	305	40.8	335	44.8	365	48.8	395	52.8
276	36.9	306	40.9	336	44.9	366	49.0	396	53.0
277	37.1	307	41.1	337	45.1	367	49.1	397	53.1
278	37.2	308	41.2	338	45.2	368	49.2	398	53.2
279	37.3	309	41.3	339	45.3	369	49.4	399	53.4
280	37.5	310	41.5	340	45.5	370	49.5	400	53.5
281	37.6	311	41.6	341	45.6	371	49.6	401	53.6
282	37.7	312	41.7	342	45.8	372	49.8	402	53.8
283	37.9	313	41.9	343	45.9	373	49.9	403	53.9
284	38.0	314	42.0	344	46.0	374	50.0	404	54.0
285	38.1	315	42.1	345	46.2	375	50.2	405	54.2
286	38.3	316	42.3	346	46.3	376	50.3	406	54.3
287	38.4	317	42.4	347	46.4	377	50.4	407	54.4
288	38.5	318	42.5	348	46.6	378	50.6	408	54.6
289	38.7	319	42.7	349	46.7	379	50.7	409	54.7
290	38.8	320	42.8	350	46.8	380	50.8	410	54.8
291	38.9	321	42.9	351	47.0	381	51.0	411	55.0
292	39.1	322	43.1	352	47.1	382	51.1	412	55.1
293	39.2	323	43.2	353	47.2	383	51.2	413	55.2
294	39.3	324	43.4	354	47.4	384	51.4	414	55.4
295	39.5	325	43.5	355	47.5	385	51.5	415	55.5
296	39.6	326	43.6	356	47.6	386	51.6	416	55.6
297	39.7	327	43.8	357	47.8	387	51.8	417	55.8
298	39.9	328	43.9	358	47.9	388	51.9	418	55.9

27° GRAVITY.

267	35.9	297	40.0	327	44.0	357	48.1	387	52.1
268	36.1	298	40.1	328	44.2	358	48.2	388	52.2
269	36.2	299	40.3	329	44.3	359	48.3	389	52.4
270	36.3	300	40.4	330	44.4	360	48.5	390	52.5
271	36.5	301	40.5	331	44.6	361	48.6	391	52.6
272	36.6	302	40.7	332	44.7	362	48.7	392	52.8
273	36.7	303	40.8	333	44.8	363	48.9	393	52.9
274	36.9	304	40.9	334	45.0	364	49.0	394	53.0
275	37.0	305	41.1	335	45.1	365	49.1	395	53.2
276	37.2	306	41.2	336	45.2	366	49.3	396	53.3
277	37.3	307	41.3	337	45.4	367	49.4	397	53.4
278	37.4	308	41.5	338	45.5	368	49.5	398	53.6
279	37.6	309	41.6	339	45.6	369	49.7	399	53.7
280	37.7	310	41.7	340	45.8	370	49.8	400	53.9
281	37.8	311	41.9	341	45.9	371	49.9	401	54.0
282	38.0	312	42.0	342	46.0	372	50.1	402	54.1
283	38.1	313	42.1	343	46.2	373	50.2	403	54.3
284	38.2	314	42.3	344	46.3	374	50.3	404	54.4
285	38.4	315	42.4	345	46.4	375	50.5	405	54.5
286	38.5	316	42.5	346	46.6	376	50.6	406	54.7
287	38.6	317	42.7	347	46.7	377	50.7	407	54.8
288	38.8	318	42.8	348	46.8	378	50.9	408	54.9
289	38.9	319	42.9	349	47.0	379	51.0	409	55.1
290	39.0	320	43.1	350	47.1	380	51.2	410	55.2
291	39.2	321	43.2	351	47.3	381	51.3	411	55.3
292	39.3	322	43.3	352	47.4	382	51.4	412	55.5
293	39.4	323	43.5	353	47.5	383	51.6	413	55.6
294	39.6	324	43.6	354	47.7	384	51.7	414	55.7
295	39.7	325	43.7	355	47.8	385	51.8	415	55.9
296	39.9	326	43.9	356	47.9	386	52.0	416	56.0

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

28° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
265	35.9	295	40.0	325	44.0	355	48.1	385	52.1
266	36.0	296	40.1	326	44.2	356	48.2	386	52.3
267	36.2	297	40.2	327	44.3	357	48.4	387	52.4
268	36.3	298	40.4	328	44.4	358	48.5	388	52.6
269	36.5	299	40.5	329	44.6	359	48.6	389	52.7
270	36.6	300	40.6	330	44.7	360	48.8	390	52.8
271	36.7	301	40.8	331	44.8	361	48.9	391	53.0
272	36.9	302	40.9	332	45.0	362	49.0	392	53.1
273	37.0	303	41.1	333	45.1	363	49.2	393	53.2
274	37.1	304	41.2	334	45.2	364	49.3	394	53.4
275	37.3	305	41.3	335	45.4	365	49.5	395	53.5
276	37.4	306	41.5	336	45.5	366	49.6	396	53.6
277	37.5	307	41.6	337	45.7	367	49.7	397	53.8
278	37.7	308	41.7	338	45.8	368	49.9	398	53.9
279	37.8	309	41.9	339	45.9	369	50.0	399	54.1
280	37.9	310	42.0	340	46.1	370	50.1	400	54.2
281	38.1	311	42.1	341	46.2	371	50.3	401	54.3
282	38.2	312	42.3	342	46.3	372	50.4	402	54.5
283	38.4	313	42.4	343	46.5	373	50.5	403	54.6
284	38.5	314	42.5	344	46.6	374	50.7	404	54.7
285	38.6	315	42.7	345	46.7	375	50.8	405	54.9
286	38.8	316	42.8	346	46.9	376	50.9	406	55.0
287	38.9	317	42.9	347	47.0	377	51.1	407	55.1
288	39.0	318	43.1	348	47.1	378	51.2	408	55.3
289	39.2	319	43.2	349	47.3	379	51.3	409	55.4
290	39.3	320	43.4	350	47.4	380	51.5	410	55.5
291	39.4	321	43.5	351	47.6	381	51.6	411	55.7
292	39.6	322	43.6	352	47.7	382	51.8	412	55.8
293	39.7	323	43.8	353	47.8	383	51.9	413	56.0
294	39.8	324	43.9	354	48.0	384	52.0	414	56.1

29° GRAVITY.

263	35.9	293	40.0	323	44.0	353	48.1	383	52.2
264	36.0	294	40.1	324	44.2	354	48.3	384	52.4
265	36.1	295	40.2	325	44.3	355	48.4	385	52.5
266	36.3	296	40.4	326	44.5	356	48.5	386	52.6
267	36.4	297	40.5	327	44.6	357	48.7	387	52.8
268	36.5	298	40.6	328	44.7	358	48.8	388	52.9
269	36.7	299	40.8	329	44.9	359	49.0	389	53.0
270	36.8	300	40.9	330	45.0	360	49.1	390	53.2
271	36.9	301	41.0	331	45.1	361	49.2	391	53.3
272	37.1	302	41.2	332	45.3	362	49.4	392	53.4
273	37.2	303	41.3	333	45.4	363	49.5	393	53.6
274	37.4	304	41.5	334	45.5	364	49.6	394	53.7
275	37.5	305	41.6	335	45.7	365	49.8	395	53.9
276	37.6	306	41.7	336	45.8	366	49.9	396	54.0
277	37.8	307	41.9	337	45.9	367	50.0	397	54.1
278	37.9	308	42.0	338	46.1	368	50.2	398	54.3
279	38.0	309	42.1	339	46.2	369	50.3	399	54.4
280	38.2	310	42.3	340	46.4	370	50.4	400	54.5
281	38.3	311	42.4	341	46.5	371	50.6	401	54.7
282	38.5	312	42.5	342	46.6	372	50.7	402	54.8
283	38.6	313	42.7	343	46.8	373	50.8	403	54.9
284	38.7	314	42.8	344	46.9	374	51.0	404	55.1
285	38.9	315	42.9	345	47.0	375	51.1	405	55.2
286	39.0	316	43.1	346	47.2	376	51.3	406	55.4
287	39.1	317	43.2	347	47.3	377	51.4	407	55.5
288	39.3	318	43.4	348	47.4	378	51.5	408	55.6
289	39.4	319	43.5	349	47.6	379	51.7	409	55.8
290	39.5	320	43.6	350	47.7	380	51.8	410	55.9
291	39.7	321	43.8	351	47.9	381	52.0	411	56.0
292	39.8	322	43.9	352	48.0	382	52.1	412	56.2

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

30° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
262	35.9	292	40.1	322	44.2	352	48.3	382	52.4
263	36.1	293	40.2	323	44.3	353	48.4	383	52.5
264	36.2	294	40.3	324	44.4	354	48.6	384	52.7
265	36.4	295	40.5	325	44.6	355	48.7	385	52.8
266	36.5	296	40.6	326	44.7	356	48.8	386	52.9
267	36.6	297	40.8	327	44.9	357	49.0	387	53.1
268	36.8	298	40.9	328	45.0	358	49.1	388	53.2
269	36.9	299	41.0	329	45.1	359	49.3	389	53.4
270	37.0	300	41.2	330	45.3	360	49.4	390	53.5
271	37.2	301	41.3	331	45.4	361	49.5	391	53.6
272	37.3	302	41.4	332	45.5	362	49.7	392	53.8
273	37.5	303	41.6	333	45.7	363	49.8	393	53.9
274	37.6	304	41.7	334	45.8	364	49.9	394	54.1
275	37.7	305	41.8	335	46.0	365	50.1	395	54.2
276	37.9	306	42.0	336	46.1	366	50.2	396	54.3
277	38.0	307	42.1	337	46.2	367	50.3	397	54.5
278	38.1	308	42.3	338	46.4	368	50.5	398	54.6
279	38.3	309	42.4	339	46.5	369	50.6	399	54.7
280	38.4	310	42.5	340	46.6	370	50.8	400	54.9
281	38.6	311	42.7	341	46.8	371	50.9	401	55.0
282	38.7	312	42.8	342	46.9	372	51.0	402	55.1
283	38.8	313	42.9	343	47.1	373	51.2	403	55.3
284	39.0	314	43.1	344	47.2	374	51.3	404	55.4
285	39.1	315	43.2	345	47.3	375	51.4	405	55.6
286	39.2	316	43.3	346	47.5	376	51.6	406	55.7
287	39.4	317	43.5	347	47.6	377	51.7	407	55.8
288	39.5	318	43.6	348	47.7	378	51.9	408	56.0
289	39.7	319	43.8	349	47.9	379	52.0	409	56.1
290	39.8	320	43.9	350	48.0	380	52.1	410	56.2
291	39.9	321	44.0	351	48.2	381	52.3	411	56.4

31° GRAVITY.

260	35.9	290	40.0	320	44.2	350	48.3	380	52.5
261	36.0	291	40.2	321	44.3	351	48.5	381	52.6
262	36.2	292	40.3	322	44.5	352	48.6	382	52.7
263	36.3	293	40.4	323	44.6	353	48.7	383	52.9
264	36.5	294	40.6	324	44.7	354	48.9	384	53.0
265	36.6	295	40.7	325	44.9	355	49.0	385	53.2
266	36.7	296	40.9	326	45.0	356	49.2	386	53.3
267	36.9	297	41.0	327	45.2	357	49.3	387	53.4
268	37.0	298	41.1	328	45.3	358	49.4	388	53.6
269	37.1	299	41.3	329	45.4	359	49.6	389	53.7
270	37.3	300	41.4	330	45.6	360	49.7	390	53.8
271	37.4	301	41.6	331	45.7	361	49.8	391	54.0
272	37.6	302	41.7	332	45.8	362	50.0	392	54.1
273	37.7	303	41.8	333	46.0	363	50.1	393	54.3
274	37.8	304	42.0	334	46.1	364	50.3	394	54.4
275	38.0	305	42.1	335	46.3	365	50.4	395	54.5
276	38.1	306	42.3	336	46.4	366	50.5	396	54.7
277	38.2	307	42.4	337	46.5	367	50.7	397	54.8
278	38.4	308	42.5	338	46.7	368	50.8	398	54.9
279	38.5	309	42.7	339	46.8	369	50.9	399	55.1
280	38.7	310	42.8	340	46.9	370	51.1	400	55.2
281	38.8	311	42.9	341	47.1	371	51.2	401	55.4
282	38.9	312	43.1	342	47.2	372	51.4	402	55.5
283	39.1	313	43.2	343	47.4	373	51.5	403	55.6
284	39.2	314	43.4	344	47.5	374	51.6	404	55.8
285	39.3	315	43.5	345	47.6	375	51.8	405	55.9
286	39.5	316	43.6	346	47.8	376	51.9	406	56.1
287	39.6	317	43.8	347	47.9	377	52.1	407	56.2
288	39.8	318	43.9	348	48.0	378	52.2	408	56.3
289	39.9	319	44.0	349	48.2	379	52.3	409	56.5

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

32° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
258	35.8	288	40.0	318	44.2	348	48.3	378	52.5
259	36.0	289	40.1	319	44.3	349	48.5	379	52.6
260	36.1	290	40.3	320	44.5	350	48.6	380	52.8
261	36.3	291	40.4	321	44.6	351	48.8	381	52.9
262	36.4	292	40.6	322	44.7	352	48.9	382	53.1
263	36.5	293	40.7	323	44.9	353	49.0	383	53.2
264	36.7	294	40.8	324	45.0	354	49.2	384	53.3
265	36.8	295	41.0	325	45.1	355	49.3	385	53.5
266	36.9	296	41.1	326	45.3	356	49.4	386	53.6
267	37.1	297	41.3	327	45.4	357	49.6	387	53.8
268	37.2	298	41.4	328	45.6	358	49.7	388	53.9
269	37.4	299	41.5	329	45.7	259	49.9	389	54.0
270	37.5	300	41.7	330	45.8	360	50.0	390	54.2
271	37.6	301	41.8	331	46.0	361	50.1	391	54.3
272	37.8	302	42.0	332	46.1	362	50.3	392	54.5
273	37.9	303	42.1	333	46.3	363	50.4	393	54.6
274	38.1	304	42.2	334	46.4	364	50.6	394	54.7
275	38.2	305	42.4	335	46.5	365	50.7	395	54.9
276	38.3	306	42.5	336	46.7	366	50.8	396	55.0
277	38.5	307	42.6	337	46.8	367	51.0	397	55.1
278	38.6	308	42.8	338	47.0	368	51.1	398	55.3
279	38.8	309	42.9	339	47.1	369	51.3	399	55.4
280	38.9	310	43.1	340	47.2	370	51.4	400	55.6
281	39.0	311	43.2	341	47.4	371	51.5	401	55.7
282	39.2	312	43.3	342	47.5	372	51.7	402	55.8
283	39.3	313	43.5	343	47.7	372	51.8	403	56.0
284	39.5	314	43.6	344	47.8	374	52.0	404	56.1
285	39.6	315	43.8	345	47.9	375	52.1	405	56.3
286	39.7	316	43.9	346	48.1	376	52.2	406	56.4
287	39.9	317	44.0	347	48.2	377	52.4	407	56.5

33° GRAVITY.

257	35.9	287	40.1	317	44.3	347	48.5	377	52.7
258	36.1	288	40.3	318	44.5	348	48.6	378	52.8
259	36.2	289	40.4	319	44.6	349	48.8	379	53.0
260	36.3	290	40.5	320	44.7	350	48.9	380	53.1
261	36.5	291	40.7	321	44.9	351	49.1	381	53.3
262	36.6	292	40.8	322	45.0	352	49.2	382	53.4
263	36.8	293	41.0	323	45.2	353	49.3	383	53.5
264	36.9	294	41.1	324	45.3	354	49.5	384	53.7
265	37.0	295	41.2	325	45.4	355	49.6	385	53.8
266	37.2	296	41.4	326	45.6	356	49.8	386	54.0
267	37.3	297	41.5	327	45.7	357	49.9	387	54.1
268	37.5	298	41.7	328	45.9	358	50.0	388	54.2
269	37.6	299	41.8	329	46.0	359	50.2	389	54.4
270	37.7	300	41.9	330	46.1	360	50.3	390	54.5
271	37.9	301	42.1	331	46.3	361	50.5	391	54.7
272	38.0	302	42.2	332	46.4	362	50.6	392	54.8
273	38.2	303	42.4	333	46.5	363	50.7	393	54.9
274	38.3	304	42.5	334	46.7	364	50.9	394	55.1
275	38.4	305	42.6	335	46.8	365	51.0	395	55.2
276	38.6	306	42.8	336	47.0	366	51.2	396	55.4
277	38.7	307	42.9	337	47.1	367	51.3	397	55.5
278	38.9	308	43.1	338	47.2	368	51.4	398	55.6
279	39.0	309	43.2	339	47.4	369	51.6	399	55.8
280	39.1	310	43.3	340	47.5	370	51.7	400	55.9
281	39.3	311	43.5	341	47.7	371	51.9	401	56.1
282	39.4	312	43.6	342	47.8	372	52.0	402	56.2
283	39.6	313	43.8	343	47.9	373	52.1	403	56.3
284	39.7	314	43.9	344	48.1	374	52.3	404	56.5
285	39.8	315	44.0	345	48.2	375	52.4	405	56.6
286	40.0	316	44.2	346	48.4	376	52.6	406	56.8

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

34° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
255	35.9	285	40.1	315	44.3	345	48.5	375	52.7
256	36.0	286	40.2	316	44.4	346	48.7	376	52.9
257	36.1	287	40.4	317	44.6	347	48.8	377	53.0
258	36.3	288	40.5	318	44.7	348	49.0	378	53.2
259	36.4	289	40.6	319	44.9	349	49.1	379	53.3
260	36.6	290	40.8	320	45.0	350	49.2	380	53.4
261	36.7	291	40.9	321	45.1	351	49.4	381	53.6
262	36.8	292	41.1	322	45.3	352	49.5	382	53.7
263	37.0	293	41.2	323	45.4	353	49.6	383	53.9
264	37.1	294	41.3	324	45.6	354	49.8	384	54.0
265	37.3	295	41.5	325	45.7	355	49.9	385	54.1
266	37.4	296	41.6	326	45.8	356	50.1	386	54.3
267	37.5	297	41.8	327	46.0	357	50.2	387	54.4
268	37.7	298	41.9	328	46.1	358	50.4	388	54.6
269	37.8	299	42.1	329	46.3	359	50.5	389	54.7
270	38.0	300	42.2	330	46.4	360	50.6	390	54.9
271	38.1	301	42.3	331	46.6	361	50.8	391	55.0
272	38.2	302	42.5	332	46.7	362	50.9	392	55.1
273	38.4	303	42.6	333	46.8	363	51.1	393	55.3
274	38.5	304	42.8	334	47.0	364	51.2	394	55.4
275	38.7	305	42.9	335	47.1	365	51.3	395	55.6
276	38.8	306	43.0	336	47.3	366	51.5	396	55.7
277	38.9	307	43.2	337	47.4	367	51.6	397	55.8
278	39.1	308	43.3	338	47.5	368	51.8	398	56.0
279	39.2	309	43.5	339	47.7	369	51.9	399	56.1
280	39.4	310	43.6	340	47.8	370	52.0	400	56.3
281	39.5	311	43.7	341	48.0	371	52.2	401	56.4
282	39.7	312	43.9	342	48.1	372	52.3	402	56.5
283	39.8	313	44.0	343	48.2	373	52.5	403	56.7
284	39.9	314	44.2	344	48.4	374	52.6	404	56.8

35° GRAVITY.

254	35.9	284	40.2	314	44.4	344	48.7	374	52.9
255	36.1	285	40.3	315	44.6	345	48.8	375	53.1
256	36.2	286	40.5	316	44.7	346	49.0	376	53.2
257	36.4	287	40.6	317	44.9	347	49.1	377	53.4
258	36.5	288	40.8	318	45.0	348	49.2	378	53.5
259	36.6	289	40.9	319	45.1	349	49.4	379	53.6
260	36.8	290	41.0	320	45.3	350	49.5	380	53.8
261	36.9	291	41.2	321	45.4	351	49.7	381	53.9
262	37.1	292	41.3	322	45.6	352	49.8	382	54.1
263	37.2	293	41.5	323	45.7	353	50.0	383	54.2
264	37.4	294	41.6	324	45.9	354	50.1	384	54.4
265	37.5	295	41.7	325	46.0	355	50.2	385	54.5
266	37.6	296	41.9	326	46.1	356	50.4	386	54.6
267	37.8	297	42.0	327	46.3	357	50.5	387	54.8
268	37.9	298	42.2	328	46.4	358	50.7	388	54.9
269	38.1	299	42.3	329	46.6	359	50.8	389	55.1
270	38.2	300	42.5	330	46.7	360	50.9	390	55.2
271	38.4	301	42.6	331	46.8	361	51.1	391	55.3
272	38.5	302	42.7	332	47.0	362	51.2	392	55.5
273	38.6	303	42.9	333	47.1	363	51.4	393	55.6
274	38.8	304	43.0	334	47.3	364	51.5	394	55.8
275	38.9	305	43.2	335	47.4	365	51.7	395	55.9
276	39.1	306	43.3	336	47.6	366	51.8	396	56.0
277	39.2	307	43.4	337	47.7	367	51.9	397	56.2
278	39.3	308	43.6	338	47.8	368	52.1	398	56.3
279	39.5	309	43.7	339	48.0	369	52.2	399	56.5
280	39.6	310	43.9	340	48.1	370	52.4	400	56.6
281	39.8	311	44.0	341	48.3	371	52.5	401	56.7
282	39.9	312	44.1	342	48.4	372	52.6	402	56.9
283	40.1	313	44.3	343	48.5	373	52.8	403	57.0

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

40° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
246	35.9	276	40.2	306	44.6	336	49.0	366	53.4
247	36.0	277	40.4	307	44.8	337	49.1	367	53.5
248	36.2	278	40.5	308	44.9	338	49.3	368	53.7
249	36.3	279	40.7	309	45.0	339	49.4	369	53.8
250	36.5	280	40.8	310	45.2	340	49.6	370	53.9
251	36.6	281	41.0	311	45.3	341	49.7	371	54.1
252	36.7	282	41.1	312	45.5	342	49.9	372	54.2
253	36.9	283	41.3	313	45.6	343	50.0	373	54.4
254	37.0	284	41.4	314	45.8	344	50.1	374	54.5
255	37.2	285	41.6	315	45.9	345	50.3	375	54.7
256	37.3	286	41.7	316	46.1	346	50.4	376	54.8
257	37.5	287	41.8	317	46.2	347	50.6	377	55.0
258	37.6	288	42.0	318	46.4	348	50.7	378	55.1
259	37.8	289	42.1	319	46.5	349	50.9	379	55.2
260	37.9	290	42.3	320	46.7	350	51.0	380	55.4
261	38.1	291	42.4	321	46.8	351	51.2	381	55.5
262	38.2	292	42.6	322	46.9	352	51.3	382	55.7
263	38.4	293	42.7	323	47.1	353	51.5	383	55.8
264	38.5	294	42.9	324	47.2	354	51.6	384	56.0
265	38.6	295	43.0	325	47.4	355	51.8	385	56.1
266	38.8	296	43.2	326	47.5	356	51.9	386	56.3
267	38.9	297	43.3	327	47.7	357	52.0	387	56.4
268	39.1	298	43.5	328	47.8	358	52.2	388	56.6
269	39.2	299	43.6	329	48.0	359	52.3	389	56.7
270	39.4	300	43.7	330	48.1	360	52.5	390	56.9
271	39.5	301	43.9	331	48.3	361	52.6	391	57.0
272	39.7	302	44.0	332	48.4	362	52.8	392	57.1
273	39.8	303	44.2	333	48.5	363	52.9	393	57.3
274	39.9	304	44.3	334	48.7	364	53.1	394	57.4
275	40.1	305	44.5	335	48.8	365	53.2	395	57.6

43° GRAVITY.

242	35.9	272	40.4	302	44.8	332	49.3	362	53.7
243	36.1	273	40.5	303	45.0	333	49.4	363	53.9
244	36.2	274	40.6	304	45.1	334	49.5	364	54.0
245	36.3	275	40.8	305	45.2	335	49.7	365	54.1
246	36.5	276	40.9	306	45.4	336	49.8	366	54.3
247	36.6	277	41.1	307	45.5	337	50.0	367	54.4
248	36.8	278	41.2	308	45.7	338	50.1	368	54.6
249	36.9	279	41.4	309	45.8	339	50.3	369	54.7
250	37.1	280	41.5	310	46.0	340	50.4	370	54.9
251	37.2	281	41.7	311	46.1	341	50.6	371	55.0
252	37.4	282	41.8	312	46.3	342	50.7	372	55.2
253	37.5	283	42.0	313	46.4	343	50.9	373	55.3
254	37.7	284	42.1	314	46.6	344	51.0	374	55.5
255	37.8	285	42.3	315	46.7	345	51.2	375	55.6
256	38.0	286	42.4	316	46.9	346	51.3	376	55.8
257	38.1	287	42.6	317	47.0	347	51.5	377	55.9
258	38.3	288	42.7	318	47.2	348	51.6	378	56.1
259	38.4	289	42.9	319	47.3	349	51.8	379	56.2
260	38.6	290	43.0	320	47.5	350	51.9	380	56.4
261	38.7	291	43.2	321	47.6	351	52.1	381	56.5
262	38.9	292	43.3	322	47.8	352	52.2	382	56.7
263	39.0	293	43.5	323	47.9	353	52.4	383	56.8
264	39.2	294	43.6	324	48.1	354	52.5	384	57.0
265	39.3	295	43.8	325	48.2	355	52.7	385	57.1
266	39.5	296	43.9	326	48.4	356	52.8	386	57.3
267	39.6	297	44.1	327	48.5	357	53.0	387	57.4
268	39.8	298	44.2	328	48.7	358	53.1	388	57.6
269	39.9	299	44.4	329	48.8	359	53.3	389	57.7
270	40.1	300	44.5	330	49.0	360	53.4	390	57.9
271	40.2	301	44.7	331	49.1	361	53.6	391	58.0

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

44° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
240	35.8	270	40.2	300	44.7	330	49.2	360	53.7
241	35.9	271	40.4	301	44.9	331	49.3	361	53.8
242	36.1	272	40.5	302	45.0	332	49.5	362	54.0
243	36.2	273	40.7	303	45.2	333	49.6	363	54.1
244	36.4	274	40.8	304	45.3	334	49.8	364	54.3
245	36.5	275	41.0	305	45.5	335	49.9	365	54.4
246	36.7	276	41.1	306	45.6	336	50.1	366	54.6
247	36.8	277	41.3	307	45.8	337	50.2	367	54.7
248	37.0	278	41.4	308	45.9	338	50.4	368	54.9
249	37.1	279	41.6	309	46.1	339	50.5	369	55.0
250	37.3	280	41.7	310	46.2	340	50.7	370	55.2
251	37.4	281	41.9	311	46.4	341	50.8	371	55.3
252	37.6	282	42.0	312	46.5	342	51.0	372	55.5
253	37.7	283	42.2	313	46.7	343	51.1	373	55.6
254	37.9	284	42.3	314	46.8	344	51.3	374	55.8
255	38.0	285	42.5	315	47.0	345	51.4	375	55.9
256	38.2	286	42.6	316	47.1	346	51.6	376	56.0
257	38.3	287	42.7	317	47.3	347	51.7	377	56.2
258	38.5	288	42.9	318	47.4	348	51.9	378	56.3
259	38.6	289	43.1	319	47.6	349	52.0	379	56.5
260	38.8	290	43.2	320	47.7	350	52.2	380	56.6
261	38.9	291	43.4	321	47.9	351	52.3	381	56.8
262	39.1	292	43.5	322	48.0	352	52.5	382	56.9
263	39.2	293	43.7	323	48.2	353	52.6	383	57.1
264	39.4	294	43.8	324	48.3	354	52.8	384	57.2
265	39.5	295	44.0	325	48.5	355	52.9	385	57.4
266	39.6	296	44.1	326	48.6	356	53.1	386	57.5
267	39.8	297	44.3	327	48.7	357	53.2	387	57.7
268	39.9	298	44.4	328	48.9	358	53.4	388	57.8
269	40.1	299	44.6	329	49.0	359	53.5	389	58.0

45° GRAVITY.

240	36.0	270	40.5	300	45.0	330	49.5	360	54.0
241	36.2	271	40.7	301	45.2	331	49.7	361	54.2
242	36.3	272	40.8	302	45.3	332	49.8	362	54.3
243	36.5	273	41.0	303	45.5	333	50.0	363	54.5
244	36.6	274	41.1	304	45.6	334	50.1	364	54.6
245	36.8	275	41.3	305	45.8	335	50.3	365	54.8
246	36.9	276	41.4	306	45.9	336	50.4	366	54.9
247	37.1	277	41.6	307	46.1	337	50.6	367	55.1
248	37.2	278	41.7	308	46.2	338	50.7	368	55.2
249	37.4	279	41.9	309	46.4	339	50.9	369	55.4
250	37.5	280	42.0	310	46.5	340	51.0	370	55.5
251	37.7	281	42.2	311	46.7	341	51.2	371	55.7
252	37.8	282	42.3	312	46.8	342	51.3	372	55.8
253	38.0	283	42.5	313	47.0	343	51.5	373	56.0
254	38.1	284	42.6	314	47.1	344	51.6	374	56.1
255	38.3	285	42.8	315	47.3	345	51.8	375	56.3
256	38.4	286	42.9	316	47.4	346	51.9	376	56.4
257	38.6	287	43.1	317	47.6	347	52.1	377	56.6
258	38.7	288	43.2	318	47.7	348	52.2	378	56.7
259	38.9	289	43.4	319	47.9	349	52.4	379	56.9
260	39.0	290	43.5	320	48.0	350	52.5	380	57.0
261	39.2	291	43.7	321	48.2	351	52.7	381	57.2
262	39.3	292	43.8	322	48.3	352	52.8	382	57.3
263	39.5	293	44.0	323	48.5	353	53.0	383	57.5
264	39.6	294	44.1	324	48.6	354	53.1	384	57.6
265	39.8	295	44.3	325	48.8	355	53.3	385	57.8
266	39.9	296	44.4	326	48.9	356	53.4	386	57.9
267	40.1	297	44.6	327	49.1	357	53.6	387	58.1
268	40.2	298	44.7	328	49.2	358	53.7	388	58.2
269	40.4	299	44.9	329	49.4	359	53.9	389	58.4

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

46° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
238	35.9	268	40.4	298	45.0	328	49.5	358	54.0
239	36.1	269	40.6	299	45.1	329	49.7	359	54.2
240	36.2	270	40.7	300	45.3	330	49.8	360	54.3
241	36.4	271	40.9	301	45.4	331	50.0	361	54.5
242	36.5	272	41.0	302	45.6	332	50.1	362	54.6
243	36.7	273	41.2	303	45.7	333	50.3	363	54.8
244	36.8	274	41.3	304	45.9	334	50.4	364	54.9
245	37.0	275	41.5	305	46.0	335	50.6	365	55.1
246	37.1	276	41.7	306	46.2	336	50.7	366	55.2
247	37.3	277	41.8	307	46.3	337	50.9	367	55.4
248	37.4	278	42.0	308	46.5	338	51.0	368	55.5
249	37.6	279	42.1	309	46.6	339	51.2	369	55.7
250	37.7	280	42.3	310	46.8	340	51.3	370	55.8
251	37.9	281	42.4	311	46.9	341	51.5	371	56.0
252	38.0	282	42.6	312	47.1	342	51.6	372	56.1
253	38.2	283	42.7	313	47.2	343	51.8	373	56.3
254	38.3	284	42.9	314	47.4	344	51.9	374	56.4
255	38.5	285	43.0	315	47.5	345	52.1	375	56.6
256	38.6	286	43.2	316	47.7	346	52.2	376	56.7
257	38.8	287	43.3	317	47.8	347	52.4	377	56.9
258	38.9	288	43.5	318	48.0	348	52.5	378	57.0
259	39.1	289	43.6	319	48.1	349	52.7	379	57.2
260	39.2	290	43.8	320	48.3	350	52.8	380	57.3
261	39.4	291	43.9	321	48.4	351	53.0	381	57.5
262	39.5	292	44.1	322	48.6	352	53.1	382	57.6
263	39.7	293	44.2	323	48.7	353	53.3	383	57.8
264	39.8	294	44.4	324	48.9	354	53.4	384	57.9
265	40.0	295	44.5	325	49.1	355	53.6	385	58.1
266	40.1	296	44.7	326	49.2	356	53.7	386	58.3
267	40.3	297	44.8	327	49.4	357	53.9	387	58.4

47° GRAVITY.

236	35.8	266	40.4	296	44.9	326	49.5	356	54.0
237	36.0	267	40.5	297	45.1	327	49.6	357	54.1
238	36.1	268	40.7	298	45.2	328	49.8	358	54.3
239	36.3	269	40.8	299	45.4	329	49.9	359	54.5
240	36.4	270	41.0	300	45.5	330	50.1	360	54.6
241	36.6	271	41.1	301	45.7	331	50.2	361	54.8
242	36.7	272	41.3	302	45.8	332	50.4	362	54.9
243	36.9	273	41.4	303	46.0	333	50.5	363	55.1
244	37.0	274	41.6	304	46.1	334	50.7	364	55.2
245	37.2	275	41.7	305	46.3	335	50.8	365	55.4
246	37.3	276	41.9	306	46.4	336	51.0	366	55.6
247	37.5	277	42.0	307	46.6	337	51.1	367	55.7
248	37.6	278	42.2	308	46.7	338	51.3	368	55.8
249	37.8	279	42.4	309	46.9	339	51.5	369	56.0
250	38.0	280	42.5	310	47.1	340	51.6	370	56.2
251	38.1	281	42.7	311	47.2	341	51.8	371	56.3
252	38.3	282	42.8	312	47.4	342	51.9	372	56.5
253	38.4	283	43.0	313	47.5	343	52.1	373	56.6
254	38.6	284	43.1	314	47.7	344	52.2	374	56.8
255	38.7	285	43.3	315	47.8	345	52.4	375	56.9
256	38.9	286	43.4	316	48.0	346	52.5	376	57.1
257	39.0	287	43.6	317	48.1	347	52.7	377	57.2
258	39.2	288	43.7	318	48.3	348	52.8	378	57.4
259	39.3	289	43.9	319	48.4	349	53.0	379	57.5
260	39.5	290	44.0	320	48.6	350	53.1	380	57.7
261	39.6	291	44.2	321	48.7	351	53.3	381	57.8
262	39.8	292	44.3	322	48.9	352	53.4	382	58.0
263	39.9	293	44.5	323	49.0	353	53.5	383	58.1
264	40.1	294	44.6	324	49.2	354	53.7	384	58.3
265	40.2	295	44.8	325	49.3	355	53.9	385	58.4

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

50° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
234	36.1	264	40.8	294	45.4	324	50.0	354	54.6
235	36.3	265	40.9	295	45.5	325	50.2	355	54.8
236	36.4	266	41.1	296	45.7	326	50.3	356	55.0
237	36.6	267	41.2	297	45.8	327	50.5	357	55.1
238	36.7	268	41.4	298	46.0	328	50.6	358	55.3
239	36.9	269	41.5	299	46.2	329	50.8	359	55.4
240	37.0	270	41.7	300	46.3	330	50.9	360	55.6
241	37.2	271	41.8	301	46.5	331	51.1	361	55.7
242	37.4	272	42.0	302	46.6	332	51.2	362	55.9
243	37.5	273	42.1	303	46.8	333	51.4	363	56.0
244	37.7	274	42.3	304	46.9	334	51.6	364	56.2
245	37.8	275	42.4	305	47.1	335	51.7	365	56.3
246	38.0	276	42.6	306	47.2	336	51.9	366	56.5
247	38.1	277	42.8	307	47.4	337	52.0	367	56.6
248	38.3	278	42.9	308	47.5	338	52.2	368	56.8
249	38.4	279	43.1	309	47.7	339	52.3	369	57.0
250	38.6	280	43.2	310	47.8	340	52.5	370	57.1
251	38.7	281	43.4	311	48.0	341	52.6	371	57.3
252	38.9	282	43.5	312	48.2	342	52.8	372	57.4
253	39.1	283	43.7	313	48.3	343	52.9	373	57.6
254	39.2	284	43.8	314	48.5	344	53.1	374	57.7
255	39.4	285	44.0	315	48.6	345	53.2	375	57.9
256	39.5	286	44.2	316	48.8	346	53.4	376	58.0
257	39.7	287	44.3	317	48.9	347	53.6	377	58.2
258	39.8	288	44.5	318	49.1	348	53.7	378	58.3
259	40.0	289	44.6	319	49.2	349	53.9	379	58.5
260	40.1	290	44.8	320	49.4	350	54.0	380	58.7
261	40.3	291	44.9	321	49.5	351	54.2	381	58.8
262	40.4	292	45.1	322	49.7	352	54.3	382	59.0
263	40.6	293	45.2	323	49.9	353	54.5	383	59.1

60° GRAVITY.

220	35.8	250	40.7	280	45.6	310	50.5	340	55.4
221	36.0	251	40.9	281	45.8	311	50.7	341	55.6
222	36.1	252	41.1	282	45.9	312	50.8	342	55.7
223	36.3	253	41.2	283	46.1	313	51.0	343	55.9
224	36.5	254	41.4	284	46.3	314	51.2	344	56.0
225	36.6	255	41.6	285	46.4	315	51.3	345	56.2
226	36.8	256	41.7	286	46.6	316	51.5	346	56.4
227	37.0	257	41.9	287	46.8	317	51.6	347	56.5
228	37.1	258	42.0	288	46.9	318	51.8	348	56.7
229	37.3	259	42.2	289	47.1	319	52.0	349	56.9
230	37.5	260	42.4	290	47.2	320	52.1	350	57.0
231	37.6	261	42.5	291	47.4	321	52.3	351	57.2
232	37.8	262	42.7	292	47.6	322	52.4	352	57.3
233	38.0	263	42.8	293	47.7	323	52.6	353	57.5
234	38.1	264	43.0	294	47.9	324	52.8	354	57.7
235	38.3	265	43.2	295	48.1	325	52.9	355	57.8
236	38.5	266	43.3	296	48.2	326	53.1	356	58.0
237	38.6	267	43.5	297	48.4	327	53.3	357	58.2
238	38.8	268	43.7	298	48.5	328	53.4	358	58.3
239	38.9	269	43.8	299	48.7	329	53.6	359	58.5
240	39.1	270	44.0	300	48.9	330	53.8	360	58.6
241	39.3	271	44.1	301	49.0	331	53.9	361	58.8
242	39.4	272	44.3	302	49.2	332	54.1	362	59.0
243	39.6	273	44.5	303	49.4	333	54.3	363	59.1
244	39.8	274	44.6	304	49.5	334	54.4	364	59.3
245	39.9	275	44.8	305	49.7	335	54.6	365	59.5
246	40.1	276	45.0	306	49.9	336	54.7	366	59.6
247	40.2	277	45.1	307	50.0	337	54.9	367	59.8
248	40.4	278	45.3	308	50.2	338	55.1	368	59.9
249	40.6	279	45.5	309	50.3	339	55.2	369	60.1

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

63° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
217	35.9	247	40.9	277	45.8	307	50.8	337	55.8
218	36.1	248	41.0	278	46.0	308	51.0	338	55.9
219	36.2	249	41.2	279	46.2	309	51.1	339	56.1
220	36.4	250	41.4	280	46.3	310	51.3	340	56.3
221	36.6	251	41.5	281	46.5	311	51.5	341	56.4
222	36.7	252	41.7	282	46.7	312	51.6	342	56.6
223	36.9	253	41.9	283	46.8	313	51.8	343	56.8
224	37.1	254	42.0	284	47.0	314	52.0	344	56.9
225	37.2	255	42.2	285	47.2	315	52.1	345	57.1
226	37.4	256	42.4	286	47.3	316	52.3	346	57.3
227	37.6	257	42.5	287	47.5	317	52.5	347	57.4
228	37.7	258	42.7	288	47.7	318	52.6	348	57.6
229	37.9	259	42.9	289	47.8	319	52.8	349	57.8
230	38.1	260	43.0	290	48.0	320	53.0	350	57.9
231	38.2	261	43.2	291	48.2	321	53.1	351	58.1
232	38.4	262	43.4	292	48.3	322	53.3	352	58.3
233	38.6	263	43.5	293	48.5	323	53.5	353	58.4
234	38.7	264	43.7	294	48.7	324	53.6	354	58.6
235	38.9	265	43.9	295	48.8	325	53.8	355	58.8
236	39.1	266	44.0	296	49.0	326	54.0	356	58.9
237	39.2	267	44.2	297	49.2	327	54.1	357	59.1
238	39.4	268	44.4	298	49.3	328	54.3	358	59.2
239	39.6	269	44.5	299	49.5	329	54.5	359	59.4
240	39.7	270	44.7	300	49.7	330	54.6	360	59.6
241	39.9	271	44.9	301	49.8	331	54.8	361	59.8
242	40.1	272	45.0	302	50.0	332	54.9	362	59.9
243	40.2	273	45.2	303	50.2	333	55.1	363	60.1
244	40.4	274	45.3	304	50.3	334	55.3	364	60.2
245	40.6	275	45.5	305	50.5	335	55.4	365	60.4
246	40.7	276	45.7	306	50.7	336	55.6	366	60.6

65° GRAVITY.

214	35.8	244	40.8	274	45.8	304	50.8	334	55.9
215	36.0	245	41.0	275	46.0	305	51.0	335	56.0
216	36.1	246	41.1	276	46.1	306	51.2	336	56.2
217	36.3	247	41.3	277	46.3	307	51.3	337	56.4
218	36.5	248	41.5	278	46.5	308	51.5	338	56.5
219	36.6	249	41.6	279	46.6	309	51.7	339	56.7
220	36.8	250	41.8	280	46.8	310	51.8	340	56.9
221	37.0	251	42.0	281	47.0	311	52.0	341	57.0
222	37.1	252	42.1	282	47.2	312	52.2	342	57.2
223	37.3	253	42.3	283	47.3	313	52.3	343	57.4
224	37.5	254	42.5	284	47.5	314	52.5	344	57.5
225	37.6	255	42.6	285	47.7	315	52.7	345	57.7
226	37.8	256	42.8	286	47.8	316	52.8	346	57.9
227	38.0	257	43.0	287	48.0	317	53.0	347	58.0
228	38.1	258	43.1	288	48.2	318	53.2	348	58.2
229	38.3	259	43.3	289	48.3	319	53.3	349	58.4
230	38.5	260	43.5	290	48.5	320	53.5	350	58.5
231	38.6	261	43.6	291	48.7	321	53.7	351	58.7
232	38.8	262	43.8	292	48.8	322	53.8	352	58.9
233	39.0	263	44.0	293	49.0	323	54.0	353	59.0
234	39.1	264	44.1	294	49.2	324	54.2	354	59.2
235	39.3	265	44.3	295	49.3	325	54.3	355	59.4
236	39.5	266	44.5	296	49.5	326	54.5	356	59.5
237	39.6	267	44.6	297	49.7	327	54.7	357	59.7
238	39.8	268	44.8	298	49.8	328	54.8	358	59.9
239	40.0	269	45.0	299	50.0	329	55.0	359	60.0
240	40.1	270	45.1	300	50.2	330	55.2	360	60.2
241	40.3	271	45.3	301	50.3	331	55.4	361	60.4
242	40.5	272	45.5	302	50.5	332	55.5	362	60.5
243	40.6	273	45.6	303	50.7	333	55.7	363	60.7

TABLE OF COMPARATIVE WEIGHTS AND MEASURES OF OIL—Continued.

70° GRAVITY.

Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.	Pounds.	Gallons.
210	36.0	240	41.2	270	46.3	300	51.4	330	56.6
211	36.2	241	41.3	271	46.5	301	51.6	331	56.8
212	36.4	242	41.5	272	46.6	302	51.8	332	56.9
213	36.5	243	41.7	273	46.8	303	52.0	333	57.1
214	36.7	244	41.9	274	47.0	304	52.1	334	57.3
215	36.9	245	42.0	275	47.2	305	52.3	335	57.4
216	37.1	246	42.2	276	47.3	306	52.5	336	57.6
217	37.2	247	42.4	277	47.5	307	52.6	337	57.8
218	37.4	248	42.5	278	47.7	308	52.8	338	58.0
219	37.6	249	42.7	279	47.8	309	53.0	339	58.1
220	37.7	250	42.9	280	48.0	310	53.2	340	58.3
221	37.9	251	43.0	281	48.2	311	53.3	341	58.5
222	38.1	252	43.2	282	48.4	312	53.5	342	58.6
223	38.2	253	43.4	283	48.5	313	53.7	343	58.8
224	38.4	254	43.6	284	48.7	314	53.9	344	59.0
225	38.6	255	43.7	285	48.9	315	54.0	345	59.2
226	38.8	256	43.9	286	49.1	316	54.2	346	59.3
227	38.9	257	44.1	287	49.2	317	54.4	347	59.5
228	39.1	258	44.2	288	49.4	318	54.5	348	59.7
229	39.3	259	44.4	289	49.6	319	54.7	349	59.8
230	39.4	260	44.6	290	49.7	320	54.9	350	60.0
231	39.6	261	44.8	291	49.9	321	55.0	351	60.2
232	39.8	262	44.9	292	50.1	322	55.2	352	60.4
233	40.0	263	45.1	293	50.2	323	55.4	353	60.5
234	40.1	264	45.3	294	50.4	324	55.6	354	60.7
235	40.3	265	45.5	295	50.6	325	55.7	355	60.9
236	40.5	266	45.6	296	50.8	326	55.9	356	61.0
237	40.6	267	45.8	297	50.9	327	56.1	357	61.2
238	40.8	268	46.0	298	51.1	328	56.2	358	61.4
239	41.0	269	46.1	299	51.3	329	56.4	359	61.6

85° GRAVITY.

195	36.0	225	41.5	255	47.0	285	52.5	315	58.1
196	36.1	226	41.7	256	47.2	286	52.7	316	58.3
197	36.3	227	41.9	257	47.4	287	52.9	317	58.4
198	36.5	228	42.0	258	47.6	288	53.1	318	58.6
199	36.7	229	42.2	259	47.8	289	53.3	319	58.8
200	36.9	230	42.4	260	47.9	290	53.5	320	59.0
201	37.1	231	42.6	261	48.1	291	53.6	321	59.2
202	37.2	232	42.8	262	48.3	292	53.8	322	50.4
203	37.4	233	43.0	263	48.5	293	54.0	323	59.6
204	37.6	234	43.1	264	48.7	294	54.2	324	59.7
205	37.8	235	43.3	265	48.9	295	54.4	325	59.9
206	38.0	236	43.5	266	49.0	296	54.6	326	60.1
207	38.2	237	43.7	267	49.2	297	54.8	327	60.3
208	38.4	238	43.9	268	49.4	298	54.9	328	60.5
209	38.5	239	44.1	269	49.6	299	55.1	329	60.7
210	38.7	240	44.2	270	49.8	300	55.3	330	60.8
211	38.9	241	44.4	271	50.0	301	55.5	331	61.0
212	39.1	242	44.6	272	50.1	302	55.7	332	61.2
213	39.3	243	44.8	273	50.3	303	55.9	333	61.4
214	39.5	244	45.0	274	50.5	304	56.1	334	61.6
215	39.6	245	45.2	275	50.7	305	56.2	335	61.8
216	39.8	246	45.4	276	50.9	306	50.4	336	62.0
217	40.0	247	45.5	277	51.1	307	56.6	337	62.1
218	40.2	248	45.7	278	51.3	308	56.8	338	62.3
219	40.4	249	45.9	279	51.4	309	57.0	339	62.5
220	40.6	250	46.1	280	51.6	310	57.2	340	62.7
221	40.7	251	46.3	281	51.8	311	57.3	341	62.9
222	40.9	252	46.5	282	52.0	312	57.5	342	63.1
223	41.1	253	46.6	283	52.2	313	57.7	343	63.2
224	41.3	254	46.8	284	52.4	314	57.9	344	63.4

TABLE OF THE SPECIFIC GRAVITY CORRESPONDING TO EACH DEGREE OF BAUMÉ'S HYDROMETER; ALSO, THE NUMBER OF POUNDS CONTAINED IN ONE UNITED STATES GALLON AT 60° F.

Baumé.	Specific gravity.	In one gallon.	Baumé.	Specific gravity.	In one gallon.
Deg.	*Deg.*	*Pounds.*	*Deg.*	*Deg.*	*Pounds.*
10	1.0000	8.33	43	0.8092	6.74
11	0.9929	8.27	44	0.8045	6.70
12	0.9859	8.21	45	0.8000	6.66
13	0.9790	8.16	46	0.7954	6.63
14	0.9722	8.10	47	0.7909	6.59
15	0.9655	8.04	48	0.7865	6.55
16	0.9589	7.99	49	0.7821	6.52
17	0.9523	7.93	50	0.7777	6.48
18	0.9459	7.88	51	0.7734	6.44
19	0.9395	7.83	52	0.7692	6.41
20	0.9333	7.78	53	0.7650	6.37
21	0.9271	7.72	54	0.7608	6.34
22	0.9210	7.67	55	0.7567	6.30
23	0.9150	7.62	56	0.7526	6.27
24	0.9090	7.57	57	0.7486	6.24
25	0.9032	7.53	58	0.7446	6.20
26	0.8974	7.48	59	0.7407	6.17
27	0.8917	7.43	60	0.7368	6.14
28	0.8860	7.38	61	0.7329	6.11
29	0.8805	7.34	62	0.7290	6.07
30	0.8750	7.29	63	0.7253	6.04
31	0.8695	7.24	64	0.7216	6.01
32	0.8641	7.20	65	0.7179	5.98
33	0.8588	7.15	66	0.7142	5.95
34	0.8536	7.11	67	0.7106	5.92
35	0.8484	7.07	68	0.7070	5.89
36	0.8433	7.03	69	0.7035	5.86
37	0.8383	6.98	70	0.7000	5.83
38	0.8333	6.94	75	0.6829	5.69
39	0.8284	6.90	80	0.6666	5.55
40	0.8235	6.86	85	0.6511	5.42
41	0.8187	6.82	90	0.6363	5.30
42	0.8139	6.78	95	0.6222	5.18

MEMORANDA.

One United States gallon of pure water=231 cubic inches, contains 58,318 grains (or 3779.031 grams)=8.331 pounds avoirdupois.
One imperial gallon of pure water=277.276 cubic inches, contains 70,000 grains (or 4536.029 grams)=10 pounds avoirdupois.
One cubic foot of pure water at 60° F. contains 1,000 ounces = 62.5 pounds avoirdupois.
To reduce imperial gallons to United States gallons, divide by 1.2.
To reduce United States gallons to imperial gallons, multiply by 1.2.
To reduce United States gallons to cubic feet, divide by 7.5.
To reduce cubic feet to United States gallons, multiply by 7.5.
To find the number of pounds avoirdupois in one cubic foot of any substance, multiply its specific gravity by 62.5.
To find the degree Baumé corresponding to any specific gravity:

$$\frac{140}{\text{sp. gr.}} - 130 = \text{B.}^\circ$$

To find the specific gravity corresponding to any degree Baumé:

$$\frac{140}{130 + \text{B.}^\circ} = \text{sp. gr.}$$

CHAPTER X.—PRODUCTION OF PETROLEUM IN THE UNITED STATES DURING THE CENSUS YEAR.

SECTION I.—THE CONDITIONS OF THE PROBLEM.

The localities which furnished the petroleum which entered the commerce of the United States during the census year were the region in northwestern Pennsylvania north and east of Pittsburgh; Mecca, in Trumbull county, Grafton, in Lorain county, and Washington county, Ohio; Pleasants, Wood, and Ritchie counties, West Virginia; Greene county, in southwestern Pennsylvania, and Glasgow, in Barren county, Kentucky.

The actual production of petroleum in the United States cannot be accurately given for any period of time; but an approximate estimate has been made up from all available sources of information, which is believed to be as nearly correct as can be made. The reports of the pipe-lines are believed to be correct; but they do not necessarily represent the production of oil. The statistics of production are usually made up of the total amount of oil run into the pipe-lines, an estimated amount handled by private lines and tank-cars, and "dump oil" handled in barrels, to be modified by adding or subtracting the amount of oil added to or subtracted from the stock in private and well tanks during the year.

The receipts of the incorporated pipe-lines have been reported in accordance with the requirements of a law of the state of Pennsylvania, and are easily accessible. I have received estimates of the oil handled by private lines and "dump oil", verified in some instances from independent sources, and, on the whole, I believe from well-informed and reliable parties.

The estimation of the amount of oil held in tanks at wells is at all times a problem of great difficulty. This difficulty is due to the fact that the business of producing oil is conducted in such a manner that the owners of the wells themselves do not know how much oil is in their tanks; and further, that they do not, in the aggregate, care to have the production of their wells known. Again, if the owners were anxious to have a census of the oil in tanks taken, it would have to be done simultaneously, as the amount in the tanks is constantly changing; and such concerted action as would be necessary would be beset with practical difficulties if it were unanimously agreed upon. Mr. J. C. Welch is in constant communication with a number of those producers who conduct their business in the most systematic manner, and really know from actual measurement how much oil runs into their tanks from day to day. From this exact information, and much other scarcely less reliable in its character, he makes up his daily and monthly reports, which are much the most reliable of any furnished in reference to this subject. I shall therefore quote from his reports in reference to this matter. In his report for August, 1879, he writes:

There is no accumulation of stocks at wells anywhere except in the Bradford district. In the Bradford district, as is well known, the stocks at wells are very large, generally and probably rightly estimated in the vicinity of 1,500,000 barrels. By my table, given above, of comparative stocks at wells of the same owners July 1 and August 1, I find on the Bradford stocks my returns show an increase of a little over 3 per cent. Taking this increase on, say, 1,400,000 barrels, and it would make about 45,000 barrels of July production as having gone into stocks at wells. This would be about 1,500 barrels per day, and, added to July Bradford pipe-runs, would make my estimate of the production of that district saved in July a daily average of 39,556 barrels. In districts other than Bradford I think the pipe-runs of July substantially represent the production. In the light of these facts, and bringing forward my estimate of June, I estimate the production out of the ground, with the exception of what was lost in the Bradford district in July (of which no intelligent estimate can be made), as follows:

	July.	June.
	Barrels.	*Barrels.*
Butler & Armstrong	6,569	7,000
Clarion	5,034	5,100
Bullion	1,086	1,100
O. C. & A. R	3,679	3,900
Bradford	39,556	41,600
	55,924	58,700

In his September report he says:

My returns of the stocks at wells of the same owners in the Bradford district August 1 and September 1 show great uniformity.

In his October report he writes:

The Bradford stocks at wells October 1, compared with September 1, show a decline of 7 per cent. Taking this percentage from the presumed stocks at wells in the Bradford district September 1, 1,500,000 barrels, and it makes a decrease in September of 105,000, or 3,500 barrels a day going into pipe-runs.

In November his returns from the owners of the wells showed a gain of over 5 per cent., giving 1,470,000 barrels as the stock November 1. Owing to the loss during that month, the reported stocks December 1 were 1,395,000 barrels, the same as on October 1. Referring to his reports from well owners for December, in that for January, 1880, he says:

This shows a decline in the Bradford stocks I received of 17 per cent., and substantially no change in the stocks in Butler and Clarion. Assuming a stock at the Bradford wells, December 1, of 1,400,000 barrels, which in the general estimate is not far from being right, a decline of 17 per cent. would reduce them during December [illegible],000 barrels.

In his February report he says:

The decline in the Bradford district on the above stocks in January was 6 per cent., against a decline in December of the stocks I received of 17 per cent.

His returns show a gain in February of 7 per cent., in March of 13 per cent., and in April of 14½ per cent. In his May report he states:

I have returns of 121,993 barrels of oil at 882 wells, May 1, making an average per well of 138 barrels. Taking the Bradford wells, May 1, at 6,600, it would make a total stock at those wells, May 1, of 910,800. * * * Drilling wells finished in May have been very considerable in number, and will show a high average of production, as the new territory now being operated upon between Bordell City and the Gray and Van Vleck wells has proved exceptionally rich.

In his report for June, which brings up his statistics to June 1, 1880, and closes the census year, he says:

I have received returns of 988 Bradford wells, June 1, with stocks at them, exclusive of wells that had their well stocks burned in May. These 988 wells had stocks, June 1, of 167,694 barrels, an average of 171 barrels. Taking 7,000 wells as the number in the Bradford district, June 1, and with this average the total Bradford well stocks, June 1, were 1,197,000. The large amount of oil lost in the Bradford district makes estimates on the production there an uncertain thing. The amount lost now is estimated as high as 10,000 and 12,000 barrels daily.

Mr. Welch estimated the average number of barrels per well for April as 138, and for May as 171; an increase in average well stocks during May of nearly 24 per cent. per well, and in total well stocks of over 31 per cent. In his report for August, 1880, he says:

I have received returns from 1,443 Bradford wells, August 1, showing stock at them of 270,821 barrels. The average per well is 187.6. Of these 1,443 wells, 1,078 belong to companies that have 30 wells or more, with an average per well of 187½ barrels; the other 365 wells, from companies owning less than 30 wells, show an average per well of 188⅛ barrels. This, I think, shows clearly that my average of 187.6 for the entire number of wells is not vitiated on account of the returns being mostly from the larger companies.

I think this statement is good evidence of the general accuracy of Mr. Welch's conclusions, as the 1,443 wells were about one-fifth of the whole number at that time in the Bradford district.

In an editorial article, August 1, 1879, the Oil City *Derrick* remarks:

There is a large extent of territory in the Bradford field, but it has now 4,700 producing well.

In an article the following day the same paper remarks:

The *Derrick* is generally able to back up its assertions with figures, and we have prepared a table of all wells completed in the Bradford region since drilling began in 1875, with their production each month. These figures have been carefully compiled from the monthly oil reports, and are as accurate as can possibly be obtained without visiting personally every well in the region. We believe the table below does not vary from the actual producing wells 100.

I have completed this table from the files of the *Derrick* to September 1, 1880, and have added a column showing the average initial daily production per well for the productive wells drilled each month.

TABLE SHOWING THE NUMBER OF PRODUCTIVE WELLS DRILLED EACH MONTH, AND THEIR AVERAGE INITIAL DAILY PRODUCTION FOR EACH MONTH, FROM JULY 1, 1875, TO SEPTEMBER 1, 1880, IN THE BRADFORD DISTRICT.

Month.	Productive wells drilled.	Initial daily production.	Average.
	Number.	*Barrels.*	*Barrels.*
1875.			
July	6	174	29.00
August	2	50	25.00
September	3	94	31.33
October	8	160	20.00
November	3	44	14.67
December	1	25	25.00
Total	23	547	23.78
1876.			
January	11	155	14.09
February	11	252	22.91
March	14	508	36.29
April	17	286	16.82
May	25	392	15.68
June	34	544	16.00
July	31	507	16.35
August	45	652	14.49
September	29	412	14.21
October	52	550	10.58
November	46	450	9.78
December	42	390	9.29
Total	357	5,098	14.28
1877.			
January	53	490	9.24
February	37	349	9.43
March	61	631	10.34
April	42	510	12.14
May	54	514	9.52
June	52	515	9.90
July	33	516	15.64
August	48	506	10.54
September	84	1,158	13.79
October	153	2,091	13.66
November	114	1,368	12.00
December	143	2,502	17.50
Total	874	11,150	12.76
1878.			
January	105	1,537	14.64
February	96	1,508	15.71
March	110	1,758	15.98
April	220	3,597	16.35
May	346	5,650	16.30
June	205	3,264	15.92
July	151	2,437	16.14
August	142	2,632	18.54
September	122	1,938	15.89
October	186	2,572	13.83
November	211	2,724	12.91
December	127	2,575	20.28
Total	2,021	32,192	15.93
1879.			
January	110	2,017	18.33
February	107	2,525	23.60
March	202	4,705	23.29
April	233	5,805	24.91
May	355	8,559	24.11
June	308	7,902	25.66
July	269	7,291	27.10
August	206	5,939	28.83
September	160	4,630	28.99
October	167	4,837	28.96
November	148	4,065	27.47
December	188	5,657	30.09
Total	2,458	63,941	26.07
1880.			
January	216	5,999	27.77
February	256	7,542	29.46
March	335	8,185	24.43
April	418	10,531	25.19
May	409	11,554	28.25
June	302	8,959	29.67
July	311	7,839	25.21
August	325	8,587	26.42
Total eight months	2,572	69,196	26.90
Total census year	3,080	84,141	27.32

GENERAL SUMMARY.

Years.	Productive wells drilled.	Initial daily production.	Average per well.
	Number.	*Barrels.*	*Barrels.*
1875, six months	23	547	23.78
1876, twelve months	357	5,098	14.28
1877, twelve months	874	11,150	12.76
1878, twelve months	2,021	32,192	15.93
1879, twelve months	2,453	63,941	26.07
1880, eight months	2,572	69,196	26.90
Total	8,300	182,124	21.94
At beginning of the census year	4,282	72,598	16.95
At end of the census year	7,362	156,739	21.29

An examination of this table shows that the 357 wells drilled in 1876 started off with a production of an average of only 11.48 barrels per day. At that time the Butler-Clarion district was at the height of its prosperity, with an occasional well of great value, leaving but little inducement for labor in the northern field. The 874 wells drilled the following year averaged a little better, but only 12.76 barrels per day. The 2,021 new wells of 1878 started off at a daily average of 15.93 barrels. In 1879 only 432 more wells were drilled, but their average initial daily production was 26.07 barrels, an increase of 63 per cent. The 4,282 wells that had been drilled in the four years preceding the beginning of the census year started off with a production of 72,598 barrels; the 3,080 wells drilled during the census year started off with a production of 84,141 barrels. Allowing the production of all the wells drilled previous to the census year to have been, June 1, 1879, 50 per cent. of their original flow, which is perhaps allowable when we consider that more than half were not twelve months' old, the production must have been increased during the census year 232 per cent. It is true that during this and the previous year the production of other fields had been declining, but the increased production in the Bradford district was beyond all precedent, and was due, first, to an increased number of wells, and, second, to a greatly increased average initial daily production, that average having risen from 19.41 barrels during the twelve months preceding the census year to 27.32 barrels during that year, an increase of 41.78 per cent.

Commenting on the monthly report of "oil operations" for May, 1879, the Oil City *Derrick*, in its issue of May 31, 1879, the day before the beginning of the census year, says:

As regards production and consumption, the supply and demand, we cannot discover anything in common between this and preceding years. Not one element of the outlook at the present time has a true counterpart in any preceding period. In 1874, when the market declined to about 40 cents, the outlook was bright as compared with the present. The daily production at that time was between 25,000 and 30,000 barrels. It is now not less than 50,000 or 52,000 barrels. The stock held in the oil regions then did not exceed 3,000,000 barrels. It is now not less than 7,000,000 barrels, and constantly augmenting. The decline at that time was attributable to the increased production caused by the striking of the large fourth-sand wells on the Butler county cross-belt. The territory where those wells were found was limited to a small area, and the gushers declined rapidly. Now the territory known to be prolific is almost boundless. * * * Developments in the Cole Creek district are being pushed with a persistence that bodes no good for the future price of the product. The producers are paying extravagant prices for the privilege of drilling.

On this day oil opened and closed at 73¾ cents per barrel.

June 28 the *Derrick's* special report on the petroleum market says:

We are informed by parties who know what they are talking about that the stock at the wells in the Bradford district at the present time is not less than 1,000,000 barrels.

August 29 the report for that date says:

The condition of tankage in the northern region has not improved, notwithstanding the enormous shipments during this month being full and running over. The matter is further complicated by the necessity the lines are under of emptying two 25,000-barrel tanks, which have sprung a leak. The status of the wells may be judged of from the fact that the first fifteen days of this month 60,000 barrels of wooden tankage was erected in the Bradford region, all of which is presumably full.

September 1 petroleum opened at Oil City at 65⅝ cents. The editor of the *Derrick* congratulated the trade that the monthly report for August showed fewer wells finished and but little addition to the daily production, and indulged the hope of improved prices. The report of petroleum markets for that date says:

If the well reports should show a decline, men will anxiously jump in and buy, to find ultimately that there is a sufficiency of petroleum to spare for all. *There only needs an advance of a few cents to set the walking-beam wagging and producers by the ears again, scrambling after more territory.*

The sagacity of this remark is exemplified in a remarkable manner in the history of the few months following. In the issue of September 12 the *Derrick* again warns its patrons of the dire effects of overproduction, and implores them to stop drilling, giving figures to show that the production was continually on the increase and stocks accumulating. Again, on the 20th, this paper refers to the quarrel then going on between the owners of tanks and the pipe-lines, and says:

It is easy to trace back all these troubles to overproduction. The owners of large tanks soon fill the capacity, and then seek means to have it emptied that it can be again filled from their flowing wells. Even if they put up new tanks, it is but a short time before they are filled. We hear reports of 25,000-barrel tanks being built in many of the districts; yet how slight is all this new capacity when 2,000,000 barrels and over are backed up at the wells. Still the production goes on increasing. Our specials every morning give a long list of new wells. Consider the millions of stock on hand; the markets abroad nearly glutted with refined; storage capacity in the East nearly or quite filled; every well of the thousands in the Bradford district flowing daily into tanks already full or overflowing; pumping-wells forced to shut down or pump on the ground; then look at the new rigs going up and new wells daily coming in; the market hanging dead and lifeless at a ruinous figure; and ask yourself what must be the result of all this? Every week the production is greater than the week before; there is no use denying these facts, nor shirking the results they will bring.

Again, on the 23d, the editor remarks:

The runs on Saturday (20th) and Sunday (21st) were the largest ever known in the history of the trade. They amounted to over 132,000 barrels.

In the face of this enormous production the price of oil advanced, and on the 30th of September closed at 79⅝ cents. The next day, in consequence of the decrease of rigs and completed wells in the Bradford district, it advanced to 82½ cents. The development of oil territory continued to decrease until December, and the price advanced, with occasional fluctuations, until on December 3 it touched 128½. The result of this movement was a general advance along the entire line of production and a gradual reduction of prices, culminating in the spring of 1880 in such an outflow of oil as rendered all attempts to transport it futile. The pipe-lines were taxed beyond their capacity; storage tanks and well tanks were all full, and the oil flowed out upon the ground; but the drilling went on, and the average production kept pace with the unparalleled number of wells.

The following statement gives the number of wells finished, the average number of barrels per day, and the average price of oil during the census year, divided into quarters:

	Number of wells.	Average number of barrels per day.	Average price per barrel.
First quarter	783	26.90	$0 70
Second quarter	475	28.51	85
Third quarter	660	29.00	1 10
Fourth quarter	1,162	26.05	83

The advance in price beyond $1 in December stimulated production to an extent hitherto unparalleled, and produced, near the close of the year, a reaction in prices that touched 72½ cents on the 5th of May. Thus the year opened and closed with oil at nearly the same price.

As indicated in the foregoing pages, an estimate of the amount of third-sand oil produced during the census year embraces the following items:

1. Pipe-line runs.
2. Fluctuations in well stocks.
3. Oil wasted.
4. Oil burned in tanks outside of pipe-lines.
5. Oil marketed outside the pipe-lines, otherwise known as "dump oil".

SECTION 2.—WELL STOCKS.

Mr. Welch's monthly reports of the percentage of gain or loss in well stocks in the Bradford district, and his estimates of the actual stocks per well on May 1 and June 1, 1880, being based upon a sufficient number of reliable returns of individual wells, and carefully made, I think may be taken as substantially correct. They afford the means of revising his estimates of the gross Bradford well stocks for the earlier months of the census year, which like most published estimates for that period, are excessive. Taking his estimate of the average Bradford stocks on May 1, 1880, 138 barrels per well, and the total number of productive wells which had then been drilled, 6,953, we derive 959,514 barrels as the total Bradford well stocks at that date. In the same manner, applying his average per well on June 1, 1880, 171 barrels, to the total number of productive wells that had been drilled at that date, 7,362, we reach 1,258,902 barrels as the Bradford well stocks at the close of the census year. It is true that some of these wells were doing little or nothing, but the 988 wells upon which the average of 171 barrels per well were based included all classes of wells, and I regard the average as substantially correct.

The monthly fluctuations from July 1, 1879, to May 1, 1880, were reported by Mr. Welch as follows: In July a gain of 3 per cent.; in August no change; in September a loss of 7 per cent.; in October a gain of 5⅝ per cent.; in November a loss equal to the gain in October, so that stocks stood December 1 precisely as they stood October 1; in December a loss of 17 per cent.; in January a loss of 6 per cent.; in February a gain of 7 per cent.; in March a gain of 13 per cent.; in April a gain of 14½ per cent.

This is a net increase for the ten months from July 1, 1879, to May 1, 1880, of $3\frac{465}{1000}$ per cent. But the stocks at the later date, as we have found, were 959,514; consequently the stocks July 1, 1879, were 927,379, instead of

1,400,000, which Mr. Welch gave as the general estimate of the actual well stocks at that date, and which he himself adopted. Accepting, therefore, Mr. Welch's rates of the monthly fluctuations, and his conclusions as to the stocks of May and June, 1880, as correct, and taking the increase for June, 1879, as $14\frac{1}{6}$ per cent., which is my judgment of the change for that month, we derive the following tabular statement of the Bradford well stocks for each month of the census year:

Month.	Whole number of productive wells drilled prior to the 1st of each month.	Total stocks at wells on the 1st of each month.	Number of barrels per well.	Percentage of increase or decrease of well stocks during each month. Increase.	Decrease.	Month.	Whole number of productive wells drilled prior to the 1st of each month.	Total stocks at wells on the 1st of each month.	Number of barrels per well.	Percentage of increase or decrease of well stocks during each month. Increase.	Decrease.
1879.		*Barrels.*		*Per cent.*	*Per cent.*	1880.		*Barrels.*		*Per cent.*	*Per cent.*
June	4,282	812,067	189.65	$14\frac{1}{6}$	....	January	5,728	737,319	128.72	....	6
July	4,590	927,370	202.04	3	....	February	5,944	693,080	116.60	7	....
August	4,850	955,200	196.58	....	....	March	6,200	741,596	119.61	13	....
September	5,065	955,200	188.50	....	7	April	6,535	838,003	128.23	$14\frac{1}{2}$	....
October	5,225	888,336	170.02	$5\frac{3}{8}$	....	May	6,953	959,514	138.00	$31\frac{1}{5}$	....
November	5,392	936,084	173.61	....	$5\frac{1}{10}$	June	7,362	1,258,902	171.00	....	....
December	5,540	888,336	160.35	....	17						

An inspection of this table will show that the well stocks at the close of the year were 446,835 barrels more than at the beginning.

SECTION 3.—OIL THAT WAS WASTED AND BURNED.

Of the oil that ran to waste no estimate approaching accuracy can be made. Mr. Welch says, in his report for August, 1879:

It is well known a large amount of oil went to waste in July on account of inability to take care of it. Early in the month there may have been 5,000 or 6,000 barrels per day lost in this way, and considerable loss continued most of the time during the month.

In his report for September he says:

I may say that there was scarcely any oil lost in the district in August, while in July there was a large amount, and this month there is some being lost, although probably no great amount.

In his report for June, 1880, he says:

The large amount of oil being lost in the Bradford district makes estimates on the production there an uncertain thing. The amount lost now is being estimated as high as 10,000 and 12,000 barrels daily.

On comparing these statements with the table given above, it will be seen that the losses that were reported from the unavoidable waste of oil in July, August, and September, 1879, and in May, 1880, corresponded in the first three months with those periods when the average stocks at wells were nearly 200 barrels each, and in the last instance with a sudden increase of those stocks by 31 per cent., which raised that average in one month from 138 to 171 barrels per well.

Returns from four large corporations owning 296 wells distributed in the Bradford district give a total loss from oil wasted of 13,620 barrels, an average of 46 barrels per well. These losses occurred in July, August, and September, 1879, and in May, 1880. There were nearly 5,000 wells in August, 1879, and nearly 7,000 in May, 1880. Assuming that this loss of 46 barrels per well occurred upon 6,000 wells, a total loss occurred of 276,000 barrels. I have placed this loss at 275,000 barrels, and believe this a conservative estimate, for the reason that this average is based on returns made by gentlemen who took great care to make them correct, and also because this loss occurred on the property of corporations using ample capital, with every means at their disposal to take care of their oil, if it were possible. The estimate made is under rather than over the amount actually lost.

On the 6th, 9th, and 12th of May, 1880, three very destructive fires occurred in the Bradford district. The report of operations in the issue of the Oil City *Derrick* for June 1 of that year says:

In addition to the numerous isolated rigs burned in various parts of the field previous to and since May 6, the conflagration on that day, which destroyed Rew City, also burned 54 rigs at that point, and fires in other points in the field on that day destroyed 101 rig along Foster Brook, 19 in Tram Hollow, 6 in Tuna valley, and 2 on the East branch, making a total loss on that day of 182 rigs, beside a large amount of tankage and a considerable amount of oil. But three days intervened between the fires of the 6th and the disastrous conflagration which destroyed the village of Rixford, together with 54 rigs, 3 iron tanks, and about 75,000 barrels of oil. After another interval of three days the last and greatest of the series of fires swept through Tram Hollow, totally destroying the hamlets of Otto City, Middaughville, and Oil Center, and burning 300 rigs, a 25,000-barrel tank, and a large number of smaller tanks, with nearly 100,000 barrels of oil.

This gives a total of 536 rigs destroyed in these three fires, which, together with the isolated rigs burned during the month, have led to an estimated total of 600 rigs lost by fire in May, 1880. A fair estimate of stocks at these wells would be 150 barrels per well, amounting in the aggregate to 90,000 barrels of oil burned. The

25,000-barrel tank belonged to the United Lines. Deducting this 115,000 barrels from the 175,000, there remains 60,000 barrels of oil in small tanks burned. An editorial in the *Derrick* for May 13 concerning these fires remarks:

The oil region has never suffered so severely from fire within so short a time as the last week. Beginning with the conflagration which swept away Rew City last Thursday, the flames have crept over Rixford, portions of Summit, Red Rock, Foster Brook, and Four Mile, and are now raging in the vicinity of Duke Center. The disasters caused by these fires are the natural result of peculiar circumstances. For several weeks only a limited quantity of rain has fallen, and the ground is dry and parched, while in the woods which stretch in an unbroken line from one end of the Bradford field to the other the leaves and dried branches are like tinder. Scattered through this forest stand the rigs of the oil-wells, the ground about them saturated with oil and the boilers throwing up sparks day and night. Railroads also traverse some sections of it, and every one who has seen the burned patches of grass or wood each summer by the side of the track know how prolific a source of fire the locomotive is. Add to all these favorable materials for incipient conflagrations a high wind blowing almost a gale, as it has most of the time this spring, and the producers may feel that they have been lucky in escaping so well heretofore. Beside, the operator is careless, and sets his rigs and tanks in the midst of the forest, without clearing up the brush or leaves, or making any effort to escape the consequences if a fire breaks out in his vicinity. The lower oil country escaped such widespread disaster because the land was cleared of its forest. In Butler and Clarion counties more oil was produced in cultivated fields than in woods, while in Bradford there is more wood than cleared land; hence the chances of fire are greatly increased.

In the lower country there was no accumulation of stocks at wells; none wasted nor burned. The pipe-line runs therefore represent the production of that region.

I therefore estimate the production of third-sand oil out of the ground during the census year as in section 4.

SECTION 4.—ESTIMATE OF THE PRODUCTION OF THIRD-SAND OIL DURING THE CENSUS YEAR.

	Barrels.
1. Pipe-line receipts	22,628,286
2. Gain in well stocks	a 446,855
3. Oil run to waste	275,000
4. Oil burned outside of well stocks and pipe-lines	60,000
5. "Dump oil" and oil run in private lines	578,670
Total	23,988,791

This oil was produced in—

	Barrels.
Northwestern Pennsylvania	23,835,982
Greene county, Pennsylvania	3,118
West Virginia and Washington county, Ohio	138,325
Glasgow, Kentucky	5,376
Total	23,988,791

The second-sand oil is produced near Franklin, Pennsylvania, and embraces also the B, C, D, and E grades of West Virginia oils. Of this oil there was produced in—

	Barrels.
West Virginia	68,392.88
Near Franklin, Pennsylvania	105,600.00
Grafton, Ohio	2,773.00
Total	176,765.88

Four-fifths of the first-sand oil comes from the first oil-sand of the Venango group near Franklin, Pennsylvania. The oils of this class were produced in—

	Barrels.
Franklin, Pennsylvania	86,857.00
West Virginia	12,536.00
Grafton, Ohio	1,386.00
Mecca, Ohio	900.00
Erie, Pennsylvania	25.00
Total	101,704.00

The specific gravity of this class of oils is 29.5° B. and lower. A few barrels of oil of this grade were produced on the Cumberland river, in Kentucky, but the actual figures could not be obtained. Probably the amount did not exceed 50 barrels.

The production at Smith's Ferry and Slippery Rock creek, Beaver county, Pennsylvania, has been placed by competent persons at 86,803 barrels. The following is a summary of these amounts:

	Barrels.
First-sand oil	101,704
Second-sand oil	176,766
Third-sand oil	23,988,791
Beaver county, Pennsylvania	86,803
Total	24,354,064

a By an inadvertence Professor Peckham, in preparing an abstract of this report for the Compendium, placed the gains in the Bradford well stocks at 327,852 barrels, instead of 446,855 barrels. In consequence, all the numbers into which these stocks enter were understated by 118,983 barrels.

The following is a summary of the total production of the different localities:

	Barrels.
Northwestern Pennsylvania	24,034,429
West Virginia and Washington county, Ohio	219,254
Beaver county, Pennsylvania	86,803
Glasgow, Kentucky	5,376
Grafton, Lorain county, Ohio	4,159
Greene county, Pennsylvania	3,118
Mecca, Trumbull county, Ohio	900
Erie, Pennsylvania	25
Total	24.354,064

I have been unable to visit California recently, and have not received any returns from that locality. A few thousands of barrels were produced there during the census year. A spring in Crook county, Wyoming, yielded 26 barrels of heavy lubricating oil, and others at the petroleum locality at Beaver Creek yielded 428 barrels. This production, while locally valuable, selling in some instances for $1 50 per gallon, is of little importance when considered in relation to the production of the entire country.

SECTION 5.—THE ACCUMULATION OF STOCKS.

It is evident from the preceding pages that for some time antecedent to and during the census year the production of petroleum, and especially of third-sand oil, had been in excess of any demand for it, and consequently there had been a gradual accumulation of stocks in excess of the amount required in handling the oil. This process of accumulation did not take place proportionally in all the districts producing petroleum, but took place mainly in the Bradford district of northwestern Pennsylvania.

In the Grafton and Mecca districts, Ohio, and at the Glasgow, Kentucky, district the stock of oil in tanks at wells would not probably exceed 150 barrels. The amount remained about constant during the year, as it represents only the stock necessary to the handling of the oil. The constant demand for the entire production of the Smith's Ferry district, including Slippery Rock creek, prevents any accumulation of stocks, and in consequence the well stocks are always low. These stocks, together with that in the hands of the Smith's Ferry Transportation Company, have been estimated by competent persons at 3,200 barrels on June 1, 1879. On the 31st of May, 1880, the same stocks were estimated at 3,000 barrels. In West Virginia and Washington county, Ohio, the well and tank stocks, together with the stocks held by the West Virginia Transportation Company on June 1, 1879, were 79,606 barrels, and the corresponding stocks on the 31st of May, 1880, were estimated at 50,848 barrels. In Greene county, Pennsylvania, the stocks were practically nothing.

In the heavy oil district near Franklin, Pennsylvania, there was an accumulation of this quality of oil, the stock at the beginning of the census year, allowing an estimated well stock of 3,000 barrels, being 19,898 barrels, and at the end 27,106 barrels.

In northwestern Pennsylvania, exclusive of the Franklin district, the net stocks in the custody of the pipe-lines June 1, 1879, and May 31, 1880, are represented in the following table:

	June 1, 1879.	May 31, 1880.
United Pipe Lines	$5,864,850	$9,851,885
Tide-Water Pipe Company	378,812	1,009,063
Tidioute and Titusville	189,767	270,718
Pennsylvania Transportation Company	9,855	3,271
Church run	1,751	....
Octave	11,642	14,558
Cherry Tree	4,602	....
Tidioute and Warren	11,198	15,129
Fox Farm	29,954	19,631
Charley and Shaeffer run	23,211	26,024
Emlenton	13,215	15,022
Total	6,538,357	11,225,301

To this must be added, for stocks outside the pipe-lines in the old territory above and below Oil City, as estimated by Mr. J. C. Welch, the following:

	Barrels.
June 1, 1879	293,474
May 31, 1880	382,318
Stock in iron tankage unattached to pipe-lines not otherwise given	150,000
	532,318

Mr. Welch's returns give an average of well stocks in the region outside the Bradford district of 32 barrels per well, an amount that remained practically constant throughout the year. The number of wells in this so-called "lower country" to which this average would apply is much more difficult to estimate than that of the Bradford district. During the year previous to the beginning of the census year the decline of production in the Butler and Clarion districts had been rapid, and producers had been turning their attention to the Bradford district. As the census year advanced, the decreased production of the lower country became more pronounced, and the transfer of property to the Bradford district became almost equal to an hegira. Train after train of cars, loaded with all kinds of material used about an oil-well, even to old derricks in a few instances, went up the Allegheny Valley and Oil Creek roads to Bradford. No careful record of the wells drilled in the lower country was ever kept, hence the number producing at the beginning of the census year can never be known, nor can the number be known that ceased to produce and were pulled out during that year. Different estimates place the number pulled out at equal to double or treble the number drilled, but such divergent estimates show the worthlessness of all of them. Mr. Stowell puts the number of wells in the different districts of Pennsylvania, outside of Franklin, Bradford, and Beaver, at 6,693, but upon what basis this estimate rests I do not know. The following table from Stowell's *Petroleum Reporter* will give some idea of the value of this estimate as compared with the well-known changes taking place in the localities named:

NUMBER OF WELLS IN THE PENNSYLVANIA OIL-FIELDS, BY DISTRICTS, ON THE DATES GIVEN.

Name of district.	1879.									1880.					
	Jan. 31.	May 31.	June 30.	July 31.	Aug. 31.	Sept. 30.	Oct. 31.	Nov. 30.	Dec. 31.	Jan. 31.	Feb. 28.	Mar. 31.	Apr. 30.	May 31.	Dec. 31.
Butler, Parker, Clarion	4,560	4,350	4,300	4,260	4,200	4,200	4,200	4,175	4,075	4,000	4,000	4,000	4,050	4,050	3,713
Scrubgrass	270	270	270	260	260	270	270	270	270	272	272	272	272	272	272
Reno	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Oil City	360	355	355	350	350	350	350	350	350	350	350	345	345	345	345
Rouseville	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Rynd Farm	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Columbia	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Petroleum Centre	45	43	43	43	40	40	40	40	40	40	40	40	40	40	40
Shamburg	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Titusville	750	700	680	680	660	650	650	650	650	635	635	635	635	635	625
Pithole	75	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Fagundus	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Tidioute	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
Warren	100	100	100	100	100	100	100	100	100	100	100	105	105	105	130
Total	6,905	6,693	6,623	6,568	6,485	6,485	6,485	6,460	6,360	6,272	6,272	6,272	6,322	6,322	6,000
Losses		287	70	55	83			25		88					320
Gains													50		
Wells completed		110	26	23	45	16	45	59	73	56	33	38	34	32	211
Total losses		397	96	78	128	16	45	84	73	144	33	38		32	531
Total gains													84		
Franklin	357	352	350	350	350	350	350	350	350	350	350	350	350	350	350
Wells completed		27	4	5	15	8	5	3	4	2	2	2	2	2	13
Losses		32	4	5	15	8	5	3	4	2	2	2	2	2	13

These figures show a total loss in the districts producing third-sand oil, due to wells abandoned, of 851 wells during the whole census year. The number of producing wells at the beginning of the census year was 6,693. During the year 480 wells were completed, which, added to the number producing at the beginning of the year, equals 7,173 wells. The number reported producing at the end of the year was 6,322; difference, 851. These wells were in most cases plugged with pine plugs or filled with sand.

I use these figures, not because I believe them to be correct, but because they are the only approximation to the truth now available; they vary in their subdivisions from any others published, and are not fully consistent with themselves. The *Petroleum World* gives the names of the parties who completed wells in the lower country as follows:

	Wells.	Production.	Dry.
	Number.	*Barrels.*	*Number.*
In Clarion county	61	564	16
In Butler and Armstrong counties	51	335	19
In Venango, Forest, and Warren counties	44	244	10
In Jefferson county	1	0	1
Near Byrom Center	171	2,089	30
Near Emlenton	7	27	3
Total	335	3,259	79

In the Franklin district, January 31, 1879, there were reported by Mr. Stowell 357 wells, which were reduced to 352 on May 31, 1879, the day before the census year commenced, and to 350 by June 30, continuing at that number until December 31, 1880, a period of eighteen months, during which period he reports 63 wells as having been completed. In the *Reporter* for January, 1880, he quotes a local correspondent of the *Franklin Spectator* as stating that "during the past year there were 123 wells drilled and 16 wells cleaned out and retubed. * * * The number of wells pumping January 1, 1879, was about 400, and taking the number of dry wells, 22, and the number abandoned during the year from the number pumping January 1, 1879, and the number drilled and cleaned out, it will leave the pumping wells, January 1, 1880, 475. Taking these figures, the average number of wells pumping for the year 1879 would be about 450".

Mr. Stowell reports only 80 wells of the 122 completed during 1879, and a total of 350 producing December 31, 1879, against 475 as given by the correspondent whom he quotes. Furthermore, it is highly improbable that in the old and nearly exhausted territory in the neighborhood of Rouseville and Rynd farm there should be for twenty-three months, from January 31, 1879, to December 31, 1880, 400 producing wells, and at the same time 90 at Shamburg, 150 at Fagundus, and 115 in the neighborhood of Tidioute. However, while calling attention to these manifest discrepancies, I repeat that this table furnishes the nearest approximation to the facts that is available. I shall therefore apply Mr. Welch's average of 32 barrels to 6,300 wells, and estimate the well stocks of the lower country at 201,600 barrels.

Summarized, the stocks of crude oil in the producing regions June 1, 1879, may be stated as follows:

ACCUMULATED STOCKS, JUNE 1, 1879.

	Barrels.
Pipe-line stocks, third sand	6,538,357
Well stocks, Bradford district	812,067
Well stocks, lower country	201,600
Iron-tankage stocks, outside of pipe-lines	293,474
Franklin stocks, heavy oil	19,898
Smith's Ferry	3,200
West Virginia and southern Ohio	79,606
Grafton and Mecca, Ohio, and Glasgow, Kentucky	150
	7 948,352

ACCUMULATED STOCKS, MAY 31, 1880.

	Barrels.
Pipe-line stocks, third sand	11,225,291
Well stocks, Bradford district	1,258,902
Well stocks, lower country	201,600
Iron tankage stocks, outside of pipe-lines	532,318
Franklin stocks, heavy oil	27,106
Smith's Ferry	3,000
West Virginia and southern Ohio	50,848
Grafton and Mecca, Ohio, and Glasgow, Kentucky	150
	13,299,215

From these summaries it will be seen that the total accumulated stocks in the whole country at the end of the census year was 13,299,215 barrels, and that the accumulation of stocks during the census year was 5,350,863 barrels. The stocks decreased during that year in the West Virginia and southern Ohio district 28,758 barrels; Smith's Ferry district, 200 barrels. They increased during the year in the Bradford district and lower country 5,372,613 barrels; Franklin heavy oil district, 7,208 barrels.

SECTION 6.—STATISTICS OF CAPITAL AND LABOR EMPLOYED IN THE PRODUCTION OF PETROLEUM DURING THE CENSUS YEAR.

The amount of capital that has been or that is invested in the production of petroleum is a problem involved in the deepest obscurity. Capital has often been ventured in this business legitimately without return, the investment proving a total loss. From such total loss to a return of enormous value the gradation has been by infinite steps. The actual cost of the wells which have been drilled since Drake's first well (1859) could be estimated with tolerable certainty, as the price per foot for drilling has been a well-known though fluctuating factor in investment from year to year; but what any given oil-well has cost, and upon what sum a dividend of profit or loss should be declared, is often scarcely known to the owners themselves. There are large corporations that have invested money systematically for years with uniform success; but any general estimate for the whole oil region based on the operations of such concerns would be very erroneous, for the business of such corporations has been managed with prudence and sagacity upon territory that has already been proved, and usually without great speculative risks. Producing oil has not been uniformly successful in individual enterprises, although, when taken as a whole, it may have been in a general way. The capital invested in producing oil involves as a constant and well-known factor the cost of drilling and equipping wells, and also, as a fluctuating factor, the cost of the land privilege for drilling. This varies from nothing (when the original owner of the land drills his own well or offsets its cost for an equal share with those who drill it) to a bonus of from $100 to $500 an acre, in addition to a royalty of from one-sixteenth to one-fourth of the product. In other cases the fee to the land is purchased outright for large sums before the wells are drilled. Such purchases, made where land is proved, have often been very profitable business enterprises, while on the other hand they have as often proved worthless. A certain tract of land in the Oil Creek region was purchased by A., B. & Co. for $13,000 and sold to C. for $113,500 within three months. Three months later A., B. & Co. could have bought back the land for less than $10,000, it having in the mean time been proved of little value for oil. Transactions involving the loss of large sums have been so often repeated that those familiar with the oil regions frequently declare that, vast as the wealth may be which the product of petroleum represents, the losses have been fully equal to the gains. The vast number of wells that have produced nothing, the still larger number whose production has never covered the cost of drilling, together with the millions that have been wasted through fraud and reckless speculative risks, involve the loss of a vast sum which can never be accurately estimated. The area of the Bradford field was pretty clearly outlined by the end of the census year, and there were those who were declaring with added emphasis that each month had witnessed the culmination of its production, but it has continued to pour out from 50,000 to 80,000 barrels of oil a day for the last two years. If the fee to the 68,000 acres of the Bradford field was to be sold to-morrow, the estimated value, as given by different producers, would vary by so many millions of dollars as to make such estimates worthless for statistical purposes. The fact is, the present value of the land franchise of the oil-producing region is an unknown quantity, and must be so until it ceases to have value; then its past value at any given time can be estimated. The men of conservative temperament and those of sanguine temperament differ as widely as the poles are sundered in their estimates of the value of oil property. I shall not, therefore, attempt any estimate of the value of the land franchise of the oil-producing country, but shall confine my estimates to the number of wells drilled, cost of rigs, including engines, cost of casing and tubing, total cost of wells and rigs drilled during the census year, and the number of men employed in drilling wells and in producing oil during the census year:

These estimates will be made for the upper or Bradford district, the lower country, the Franklin district, and the Beaver district, Pennsylvania; the Grafton district and the Mecca district, Ohio; the West Virginia district and Washington county, Ohio; and the Glasgow, Kentucky, district.

During the census year there were 3,080 wells completed in the Bradford district, but at the close of the year there were 58 more rigs building and wells drilling than at the beginning. In the last month in the year 536 rigs were burned, about one-half of which were rebuilt immediately, and the rebuilding of the remainder was, on an average, half completed at the close of the census year, making the rebuilding equal to 75 per cent. of the whole number burned, or 402 rigs. It is fair to assume that the 47 rigs building at the end of the year in excess of those building at the beginning were one-half completed, and that the 11 wells drilling at the end of the year in excess of those drilling at the beginning were, with rigs completed, one-half drilled. This estimate would thus place the rigs built during the census year:

Rigs for wells completed	3,080
Rigs rebuilt	402
50 per cent. of rigs building at the close in excess of those building at the beginning of the year	23
Rigs to wells drilling at the close of the year in excess of those drilling at the beginning	11
Total	3,516

Each of these rigs required in building forty days of labor, making, for all, an aggregate of 140,640 days, or, estimating 300 working days to the year, equal to the continued labor through the year of 468 men, of whom 75 per cent., or 351 men, were skilled workmen and 117 ordinary laborers. Rigs cost during the census year from $325 to $400 each, according to the cost of placing the material where it was to be used, or an average of $362.50. This would give a total investment in rigs during the year of $1,274,550, of which $316,440 represents the cost of labor, estimated at the rate of $2 50 per day for skilled workmen and $1 50 per day for ordinary laborers. Returns of the cost of rigs built in the Bradford district during the census year from three large corporations are as follows: No. 1 built 25 rigs for $10,000; average cost, $400 each. No. 2 built 50 rigs for $17,500; average cost, $350 each. No. 3 built 29 rigs for $12,500; average cost, $431 each. Average cost of 104 rigs, $384 62 each.

Each of the 3,516 rigs built during the census year required for its construction 17,000 feet of lumber, of which 9,000 feet were sawed and 8,000 feet were hewn. This amount represents an aggregate consumption of 59,772,000 feet of lumber, of which probably 30 per cent. was hard wood.

It is almost impossible to estimate, with any approximation to accuracy, the capital invested in engines and boilers. There are engines in the oil regions fifteen years old, and some of them are to be found in the Bradford district, moved up there from the lower country. I have conversed with a number of oil producers on this subject, and find their opinions quite divergent. An estimate based on these opinions and my own observations would lead me to think that at least 90 per cent. of the wells in the Bradford region are supplied with engines and 60 per cent. with boilers, and an average valuation for these engines would not exceed $100 and $200 each for the boilers. I have been informed that at least one-half the wells drilled in the Bradford district during the census year were supplied with engines and boilers from wells abandoned in the lower country, for which I make no estimate. For the other half, it is fair to assume that a large proportion, if not all, of the engines and boilers were new or nearly new. While the above estimate of valuations of boilers may be fair as applied to the whole field, it is too low by one-half for the engines and boilers purchased for new wells. I place the value, in round numbers, of—

Engines (50 per cent. of 90 per cent.) of (3,080 + 11) at $200	$278,200
Boilers (50 per cent. of 60 per cent.) of (3,080 + 11) at $400	370,800
	649,000

This would give an average valuation of $210 per well for all the boilers and engines purchased for the 3,091 wells drilled during the census year. That this valuation is not too high is further proved by returns which I have received from two large corporations with ample capital, both largely interested in the lower country and in the Bradford district. No. 1 drilled 29 wells; the boilers and engines cost $13,000. No. 2 drilled 45 wells; the boilers and engines cost $15,360. The average cost for No. 1 is $448; that for No. 2, $341. I have no doubt that a large percentage of the wells were drilled with poorer machinery than would be used by either of these parties.

The rig, boiler, and engine belong to the owner of the well; but the contractor who drills the well owns the drillers' tools and provides fuel for the engine and coal for the blacksmith. It is estimated that 2 per cent. of the wells use gas, which, practically costing nothing, reduces the number supplied with fuel to 3,024. Experienced producers estimate the consumption of fuel at an average of 100 cords of wood per well, amounting in the aggregate to 302,400 cords, and costing for cutting, at 90 cents per cord, $272,160. It is estimated that 500 men are employed in cutting wood in the Bradford district. The wood usually stands upon the land upon which the well is located, and, except for the cost of cutting, is considered of little or no value.

Each well requires for drilling two drillers and two tool-dressers, who are men skilled in the work which they perform. The tool-dressers are not blacksmiths, but men who are expert in the art of dressing tools. Each well also requires two teams, with teamsters, for hauling wood and material. From returns received from 104 wells drilled in the Bradford district in the census year, 25 drillers drilled the wells and 18 dressers dressed the tools. These wells were drilled more economically, as regards the amount of labor, than the average, as they were drilled by corporations employing very skillful men at maximum wages, from which I judge that a fair estimate would give a year's labor of a skilled workman to every two wells drilled, or, in round numbers, for the 3,086 wells drilled in the census year, a year's labor of 1,500 men, at an average rate of $3 per day. Estimating 300 working days to the year, the amount earned by them would equal $1,350,000. As many more laborers are employed, at an average compensation of $45 per month, earning an amount equal to $810,000. The outfit for drilling a well is worth $900, and is damaged an average of 25 per cent. by use in drilling one well, representing an investment of $694,350 during the census year. These sums show the cost to the contractor. The average contract price for drilling deep (2,000 feet) wells was 55 cents per foot. At this rate the 3,086 wells would represent an investment by the well-owner of $3,394,600. Such estimates are hardly worth the name of statistics, but are, I believe, as close an approximation to accuracy as can now be made.

Each well requires from 30 to 100 feet of 8-inch drive-pipe, which is driven to the bed-rock, and on an average 300 feet of casing, 5⅝ inches in diameter, and 2,000 feet of 2-inch pipe, through which the oil flows.

At an average of 50 feet of drive-pipe for each well, there were required during the census year for the 3,086 wells drilled 154,300 feet of 8-inch drive-pipe, 925,800 feet of 5⅝-inch casing, and 6,172,000 feet of 2-inch pipe.

It is extremely difficult to estimate the actual cost of this pipe, as the different manufacturers made bids for large contracts, and a proportion, impossible to ascertain accurately, was old pipe. One large corporation paid an average of $310 50 each for casing 29 wells; another an average of $210 each for 45 wells. In one case it is to be presumed a larger amount of old casing was used than in the other, but just what this difference of one-third signifies with reference to the whole number of wells it is impossible to ascertain. Prudent men, with ample capital, would sell old casing and use new, while men of limited means would purchase and use the old; but to what extent this was done it is now impossible to determine with accuracy. It is probable, however, that $210 per well is nearer an average price for casing for the entire Bradford district than $310 50. Returns from the same firms give an average expenditure of $343 per well for tubing 74 wells. These were firms using ample capital, and the average is no doubt too high for the whole field, $300 per well being without doubt an ample average cost at which to estimate tubing. Assuming that all of the drive-pipe was new and cost $3 per foot, the total cost would be as follows:

Drive-pipe	$462,900
Casing	648,060
Tubing	925,800
Total	2,036,750

The cost of torpedoes is subject to caprice. There are those who do not use them at all; some use small ones, others use very large ones. One firm torpedoed 25 wells at an aggregate cost of $9,982, average cost, $400; a second firm 29 wells for $3,000, average cost, $103; another firm 45 wells for $9,360, at an average cost of $208.

These firms and corporations are all managed by judicious, conservative men, of large experience, while a large proportion of the wells are drilled by men who operate recklessly and rely upon torpedoes to produce large and quick results. I regard $300 per well as a low estimate for torpedoes, amounting in the aggregate to $925,800.

These estimates foot up as follows:

Cost of 3,516 rigs	$1,274,550
Engines and boilers for 3,091 wells	649,000
Drilling 3,086 wells	3,394,600
Piping 3,086 wells	2,036,760
Torpedoing 3,086 wells	925,800
Total	8,280,710

Returns from eight of the largest firms and corporations doing business in the oil regions, having more than 20,000 acres under development and operating over 600 wells during the census year, give an average of five acres to one well, and assign to the land a value of $300 per acre for oil purposes. Upon this basis they estimate a general average cost of the land at $1,500 per well, and of the well itself from $2,500 to $3,000. At $2,500 each, the cost of the 3,080 wells completed during the census year would be $7,700,000; at $3,000 each the same wells would cost $9,240,000. My estimate of $8,280,710 is therefore a fair average estimate, as based upon that of the owners, of about 10 per cent. of the wells that had been drilled in the Bradford district at the beginning of the census year.

The approximate value of labor employed in building rigs was $316,440; in cutting wood, $272,160; in drilling wells, $2,160,000; total, $2,748,600. To this sum must be added the value of labor employed in operating and repairing wells already drilled, a service which requires the labor of a large number of men.

Returns from the owners of 590 wells show that they employ 275 men in pumping and gauging, and 34 men as overseers; a total of 309 men. Apply this average to the 4,000 wells in the Bradford district at the beginning of the census year, and it gives, in round numbers, 2,000 men, earning $45 per month, or an aggregate of $1,080,000, which makes up a total labor account for the Bradford field of $3,828,600.

The number of wells drilled in the lower country during the census year was 335. Their average depth has been placed at 1,400 feet, and the rigs and tools are the same as those used in the Bradford district, at the same average cost; but their lessened depth reduces the cost of both drilling and tubing. Three hundred and thirty-five rigs, at the average price of $362 50, would cost $121,437 50, and would require for their construction 5,695,000 feet of lumber, 3,015,000 of which would be sawed soft lumber and 2,680,000 hewn lumber. These wells would require for drilling 33,500 cords of wood, the cutting of which would cost $30,150.

I estimate the cost of engines and boilers in this district as averaging $300 per well, which, for 335 wells, would give a valuation of $100,500. Estimating the average of 50 feet of drive-pipe per well at $3 per foot, casing at $210 and tubing at $200 per well for an average depth of 1,400 feet, the cost of casing and tubing the 335 wells drilled in the lower country would be as follows:

Drive-pipe, 8-inch, 16,750 feet	$50,250
Casing, 5⅝-inch, 100,500 feet	70,350
Tubing, 2-inch, 469,000 feet	67,000

The drilling of 1,400-foot wells was worth during the census year 60 cents per foot, and at that rate the drilling of the 335 wells in the lower country cost $281,400.

Summarized, these estimates foot up as follows:

335 rigs, at $362 50 each	$121,437
Engines and boilers for 335 wells, at an average cost per well of $300	100,500
335 wells, drilled 1,400 feet each, at 60 cents per foot	281,400
Drive-pipe	50,250
Casing	70,350
Tubing	67,000
Total	690,937

The general estimate given by producers of large experience that 1,400-foot wells cost about $2,000 each confirms these detailed estimates; and at this rate the 335 wells would cost $670,000.

The employment of labor in the lower country is divided between drilling wells and caring for those already drilled. Unlike the wells in the Bradford district, nearly all of which were flowing during the census year, those of the lower country were all pumping-wells. The labor required in building 335 rigs, estimating 30 days of skilled labor at $2 50 and 10 days of ordinary labor at $1 50 per day, amounts to the labor of 33 carpenters, $25,125; 11 laborers, $5,025.

In drilling the wells there were required 175 skilled workmen at $3 per day, and as many more laborers at $45 per month, which would amount in a year as follows: 175 skilled workmen, at $3 per day, 300 days, $157,500; 175 laborers, $45 per month, $94,500.

The investment in drillers' tools, on an average of five wells to a set, amounts to $60,300.

The employment of labor in the lower country in the care of wells is proportionally greater, for reasons already stated.

Three corporations, owning 112 wells, all in the lower country, employed 74 men to care for them, four-fifths of whom were engaged in pumping and gauging. As these wells belonged to corporations having a thoroughly organized business, it is to be presumed that a minimum number of men are employed. Using these numbers as the basis of an average, the 6,000 wells that were cared for in the lower country during the census year required the services of 3,960 men; but I think it is fair to assume that 4,500 men were employed, at an average rate of compensation of $50 per month, which would make the aggregate sum paid in wages $2,700,000. The approximate value of labor employed in the lower country is, therefore—

In rig-building	$30,150
In cutting wood	30,150
In drilling wells	252,000
In caring for wells	2,700,000
Total	3,012,300

In estimating the investment in drilling wells and the value of labor employed in the Franklin district entirely different conditions must be considered. The wells are not more than 100 feet deep, and cost, on an average, only about $400 each. As a portion of the productive territory is owned by farmers, who in some instances drill the wells themselves and pump them at intervals as other work may slacken, it will be readily perceived that a much larger number of persons are interested in the production of oil, and find partial occupation in it, than would be necessary to carry on the business if constantly employed. In the most productive portion of the field the wells are constantly pumped six days in the week on the sucker-rod plan, from 12 to 40 wells being by this method pumped by one engine. There were 475 productive wells January 1, 1880, and I shall assume that 450 was the average for the census year, of which 400 were pumped constantly. The rigs used here are only about 30 feet in height.

Drilling in this district was comparatively active during the census year, an average of about 10 wells per month having been completed, with an average daily production of about 2 barrels each. The drilling of these wells could not have employed constantly more than 50 men, including the rig-builders, and their care, allowing 5 men to 20 wells, would employ 120 men. Summarized, the items appear as follows:

Cost of 120 wells	$48,000
Labor of 50 men, at $50 per month	30,000
Labor of 120 men, at $50 per month	72,000

In the Beaver district it is estimated there were 200 wells, 15 wells being drilled during the year. These wells are about 600 feet deep, and cost about $700 each. The rigs used are low and comparatively inexpensive, and the pumping is done with sucker-rods. Probably 75 men, at $50 per month, is a maximum estimate for the labor employed in this district. Summarized the items appear as follows:

Cost of 15 wells, at $700 each	$10,500
Labor of 75 men for one year, at $50 per month	45,000

At Belden and at Grafton, Lorain county, Ohio, 72 paying and twice as many more unproductive wells have been drilled, generally from 60 to 250 feet in depth, the deepest yielding the lightest oil, of which about 20 were producing during the census year. Wells cost here from $30 to $40 each, exclusive of the rig and machinery, which are moved about as required. The oil industry here gives employment to about 10 men, and their labor, at $50 per month, for one year, amounts to $6,000.

In the Mecca district the cost of operating for oil is reduced to a minimum. The wells are from 40 to 70 feet deep. A rig costs only $20, and is moved about as required. A rig was hired, and three wells were put down at a total expense of $100.

Probably 20 wells, at an estimated cost of $40 each, were drilled during the census year. It is estimated that 15 men are fully employed here in producing oil. Very few wells are pumped by machinery, a wooden conductor being carried down to the rock; and after the well is drilled and the production has run down everything is removed but this conductor. The well is then pumped at intervals with a sand pump. There are several hundred wells that are pumped in this manner, but the exact number would be very difficult to ascertain. Summarized, the items appear as follows: Cost of 20 wells, at $40, $800; labor of 15 men, at $50 per month, one year, $9,000.

The West Virginia and Washington county (Ohio) oil district is the most peculiar in the country. It has produced oil for a long time, and yields a great variety. The number of wells in this region is about 600. Some of them, yielding heavy and valuable oil, have been pumped since 1865 and 1866; others, yielding lighter oils, have been abandoned, and others still that had been abandoned have been cleaned out and pumping has been resumed. A few wells are being drilled there every year. In the absence of records, it has been estimated that the number of pumping wells has remained about the same for several years, the new ones about equaling those abandoned. I could not ascertain that more than 120 wells were drilled in the district during the census year, the depths varying from 150 to 1,500 feet, as the well penetrates the different horizons at which oil is found. Very few wells, however, have been put down to the 1,500-foot level, and perhaps an equally small number have proved remunerative at the 150- to 200-foot level. The average depth is about 750 feet, and the average cost is estimated at $1,000. Both skilled and ordinary labor is cheaper in this section than in northwestern Pennsylvania, skilled labor being reported here to be worth during the census year from $2 to $2 50 per day, against $2 50 to $3 50 in Pennsylvania, and ordinary labor from $1 to $1 50, against $1 75 to $2 in Pennsylvania. A large number of wells are pumped here by one engine, but instead of a sucker-rod connection the pump rod is attached to a wheel, over which passes an endless wire rope. The uneven surface of the country, as well as the greater depth of the wells, renders this method of transmitting power necessary; but while it is more expensive, it is more reliable.

From returns received I estimate the average cost of the 120 rigs built during the census year at $250 each, requiring twenty-four days of skilled and eight days of ordinary labor and 12,000 feet of lumber in their construction. Coal is used as fuel in this section, the wells often passing through the veins. I estimate very few, if any, new engines and boilers in use for drilling these wells. This section has produced oil since 1861, and some of the machinery used is very old. In drilling the machinery is attached to a gang of wells by an endless rope, and is run without any increase in the expense account. Wooden conductors are used. I estimate an average expense of $125 as ample to cover the cost of casing, and an average of 500 feet for each would include all of the tubing required. The cost per foot for drilling would not vary much from 60 cents per foot. Summarized, these estimates appear as follows:

120 rigs, at $250 each	$30,000
120 wells drilled	54,000
Casing, $125 each	15,000
Tubing	9,000
	108,000

The labor employed for the year is estimated as follows:

In rig-building, 10 men, earning	$7,200
In rig-building, 3 men, earning	960
In drilling wells, 25 men, earning	15,000
In caring for wells, 250 men, earning	150,000
	173,160

On Boyd's creek, near Glasgow, Kentucky, there were five wells in operation during the census year, furnishing employment to seven men, including teamsters, at an average compensation of $35 per month, the wages amounting to $2,940.

The following table represents in a tabulated form the statistics of this section:

STATISTICS OF THE INVESTMENT OF CAPITAL AND THE EMPLOYMENT OF LABOR IN THE PRODUCTION OF PETROLEUM DURING THE YEAR ENDING MAY 31, 1880.

Name of district.	No. of wells drilled.	No. of dry holes.	No. of rigs built.	Cost of rigs.	Cost of engines and boilers.	Cost of drive-pipe.	Cost of casing.	Cost of tubing.	Cost of torpedoes.	Cost of drilling.	Total cost of wells.	Estimated number of skilled workmen.	Average rate of wages.
Bradford, Pennsylvania	3,080	58	3,516	$1,274,550	$649,000	$402,000	$648,060	$925,800	$925,800	$3,394,600	$8,280,710	1,851	$2 50—4 00
Lower country, Pennsylvania	335	70	335	121,437	100,500	50,250	70,350	67,000	....	281,400	690,937	208	2 50—4 00
Franklin, Pennsylvania	120	15	120	....	....	....	....	....	....	....	48,000	15	2 50—4 00
Beaver county, Pennsylvania	15	....	15	....	....	....	....	....	....	....	10,500	12	2 50—4 00
Grafton, Ohio	....	....	....	....	....	....	....	....	....	....	....	....	....
Mecca, Ohio	20	....	....	....	....	....	....	....	....	....	800	....	....
West Virginia and southern Ohio	120	....	120	30,000	....	....	15,000	9,000	....	54,000	120,000	25	2 00—2 50

Name of district.	Estimated number of ordinary laborers.	Average rate of wages.	Estimated number of wood-choppers.	Rate paid per cord.	Total number of men employed.	Total amount of wages paid.	Estimated number of men employed in drilling wells.	Estimated number of men employed in caring for wells.	Estimated amount of feet of lumber used in rigs.	Estimated amount of cords of fuel used in drilling wells.	Total production in barrels.
Bradford, Pennsylvania	3,617	$1 50—2 00	500	$0 90	5,968	$3,828,600	3,000	2,000	59,772,000	302,400	23,828,589
Lower country, Pennsylvania	4,686	1 50—2 00	50	....	4,944	3,012,300	350	4,500	5,695,000	33,500	
Franklin, Pennsylvania	155	1 50—2 00	....	....	170	102,000	50	120	600,000	....	86,857
Beaver county, Pennsylvania	63	1 50—2 00	....	....	75	45,000	10	60	225,000	....	86,803
Grafton, Ohio	....	....	....	....	10	6,000	....	10	....	....	4,150
Mecca, Ohio	....	....	....	....	15	9,000	....	15	....	....	900
West Virginia and southern Ohio	263	1 00—1 50	....	....	288	173,160	25	250	1,440,000	....	219,254
Glasgow, Kentucky	....	....	....	....	7	2,940	....	....	....	....	5,376
Greene county, Pennsylvania	....	....	....	....	....	....	....	....	....	....	3,118
Erie, Pennsylvania	....	....	....	....	....	....	....	....	....	....	25

Cost of raising oil: Flowing wells in the Bradford district, 6 to 8 cents per barrel; pumping wells in the lower country, 60 to 80 cents; pumping wells in Franklin district, $3 per barrel.

To this may be added the following table, showing the estimated number of wells at the beginning and the end of the census year in the United States east of the Mississippi river:

Name of district.	Estimated number of producing wells June 1, 1879.	Estimated number of producing wells May 31, 1880.	Number completed during census year.	Dry holes.
Bradford, Pennsylvania	4,282	7,362	3,080	53
Lower country, Pennsylvania	6,693	6,322	335	79
Franklin, Pennsylvania	400	500	120	15
Beaver county, Pennsylvania	200	200	15	?
Grafton, Ohio	20	20	?	?
Mecca, Ohio	?	?	20	?
West Virginia and southern Ohio	500	600	120	?
Glasgow, Kentucky	5	5	....	....
Total	12,100	15,009	3,690	147

SECTION 7.—GENERAL STATISTICS RELATING TO THE PRODUCTION OF THIRD-SAND PETROLEUM.

In illustration of this section I have been so fortunate as to secure the accompanying diagrams, prepared by Mr. Charles A. Ashburner, of Philadelphia, especially for this work, from the statistical tables of Stowell's *Petroleum Reporter*. No. I is a graphic representation of the total production by years of the different districts, by which the date of discovery, expansion, and contraction of the production of the different districts is noted; No. II shows the comparative volume of the total production of the different districts. No. III shows the comparative expansion and contraction of the total yearly production, with the total value in greenbacks and gold, from 1859 to 1880, inclusive. On pages 149, 150, and 151 are statistical tables from another source, which vary only slightly from the preceding in the aggregate, and present the matter in detail. On page 150 is a statistical statement, made by the United Pipe Lines, that offers its own explanation. On page 151 is a table giving some comparative miscellaneous pipe-line statistics that are included in the census year, taken from the *Titusville Herald* of April 11, 1881, except the averages for the census year. The following estimate of stocks in the oil region on the dates named is given for what it is worth, as the authority is unknown:

	Barrels.		Barrels.
February, 1868	534,000	February, 1874	1,248,919
February, 1869	264,000	February, 1875	4,250,000
February, 1870	340,751	February, 1876	3,585,143
February, 1871	537,000	February, 1877	2,604,128
February, 1872	623,048	February, 1878	3,555,342
February, 1873	1,085,435	February, 1879	5,385,523

STATEMENT SHOWING THE YEARLY PRODUCTION, AVERAGE YEARLY PRICE, AND VALUE, IN CURRENCY, OF ALL OIL PRODUCED FROM 1860 TO DECEMBER 31, 1880, BOTH INCLUSIVE.

Year.	Number of barrels.	Average price per barrel.	Amount.
Total	156,888,331	....	$334,871,063 84
1860	500,000	$9 60	4,800,000 00
1861	2,113,609	49	1,035,668 41
1862	3,056,690	1 05	3,209,524 50
1863	2,611,309	3 15	8,225,623 35
1864	2,116,109	9 87½	20,896,576 37
1865	2,497,700	6 59	16,459,843 00
1866	3,597,700	3 74	13,455,398 00
1867	3,347,300	2 41	8,066,993 00
1868	3,646,117	3 62½	13,217,174 12
1869	4,215,000	5 63	23,730,450 00
1870	5,260,745	3 89¾	20,503,753 63
1871	5,205,341	4 34	22,591,179 94
1872	5,890,248	3 64	21,440,502 72
1873	9,890,964	1 83	18,100,464 12
1874	10,809,852	1 17	12,647,526 84
1875	8,787,506	1 35	11,863,133 10
1876	8,968,906	2 56¼	22,982,821 62
1877	13,135,771	2 42	31,788,565 82
1878	15,163,462	1 19	18,044,519 78
1879	20,041,581	85⅞	17,210,707 68
1880	26,032,421	94½	24,600,637 84

Average price per barrel for 21 years, $2 13+.

STATEMENT OF THE NUMBER OF BARRELS OF OIL PRODUCED FROM AUGUST 26, 1859, TO DECEMBER 31, 1880, BY YEARS AND BY COUNTIES, IN THE OIL REGIONS OF PENNSYLVANIA AND SOUTHERN NEW YORK.

Years.	Number of barrels.	State and county.
Total	156,153,807	
1859	1,000	Venango county, Pennsylvania.
1860	500,000	Venango, Forest, Crawford, and Warren, Pennsylvania.
1861	2,113,609	Do.
1862	2,056,690	Do.
1863	2,611,369	Do.
1864	2,116,109	Do.
1865	2,497,700	Venango, with Clarion and Armstrong.
1866	3,597,700	Venango, with Cattaraugus county, New York.
1867	3,347,300	Do.
1868	3,715,700	Do.
1869	4,215,100	Do.
1870	5,659,000	Venango, with Butler county, Pennsylvania.
1871	5,202,710	Do.
1872	5,985,635	Do.
1873	9,882,010	Venango, with McKean county, Pennsylvania.
1874	10,920,435	Do.
1875	8,788,470	Do.
1876	8,952,355	Do.
1877	13,120,780	Do.
1878	15,159,180	Do.
1879	19,741,755	Do.
1880	25,960,260	Do.

TOTAL PRODUCTION OF CRUDE PETROLEUM IN PENNSYLVANIA OIL-FIELDS FROM 1859 TO DECEMBER 31, 1880, BOTH INCLUSIVE, DIVIDED INTO PRODUCING DIVISIONS AND DISTRICTS.

Years.	Oil Creek division.	Pithole district.	Central Allegheny division.	Lower Allegheny division.	Tidioute district.	Clarion division.	Bradford division.	Bullion district.	Warren division.	Beaver division.	Yearly total of all districts.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
Total	35,517,217	4,816,298	6,482,900	37,342,978	4,674,345	20,381,638	44,574,921	2,312,190	448,213	339,631	156,890,331
1859	2,000										2,000
1860	500,000										500,000
1861	2,113,609										2,113,609
1862	3,056,690										3,056,690
1863	2,611,309										2,611,309
1864	2,116,109										2,116,109
1865	1,585,200	912,500									2,497,700
1866	2,502,700	1,095,000									3,597,700
1867	2,393,300	954,000									3,347,300
1868	3,072,617	547,500	26,000								3,646,117
1869	3,762,500	365,000	22,000	45,000	20,500						4,215,000
1870	3,039,528	173,585	813,150	918,644	315,838						5,260,745
1871	2,040,263	182,054	1,083,386	1,091,458	497,887	310,293					5,205,341
1872	1,529,685	145,065	881,140	1,658,080	847,199	829,079					5,890,248
1873	1,094,380	119,864	851,934	4,402,563	895,083	2,526,231					9,890,964
1874	734,247	55,770	564,978	5,160,265	373,325	3,921,267					10,809,852
1875	504,639	35,130	343,905	4,712,702	351,407	2,821,214	18,509				8,787,506
1876	611,884	37,450	333,640	4,755,623	354,284	2,377,700	382,768	64,220	51,337		8,968,906
1877	834,858	60,380	474,262	5,431,072	312,700	3,012,120	1,490,481	1,306,442	151,871	62,085	13,135,771
1878	680,948	60,000	368,710	4,552,815	308,780	2,276,408	6,208,740	505,265	108,300	92,490	15,163,462
1879	380,400	36,500	558,652	2,876,787	227,900	1,438,342	14,096,750	289,501	45,550	82,100	20,041,581
1880	335,342	36,500	166,143	1,737,969	168,542	868,984	22,377,058	146,672	91,655	102,956	26,032,421

RECAPITULATION.

	Barrels.
Oil Creek division, including Shamburg, Pleasantville, and Enterprise	35,517,217
Pithole district, including Holderman, Morey, and Ball farms	4,816,298
Central Allegheny division, including Scrubgrass to West Hickory	6,482,900
Lower Allegheny division, including Butler and Armstrong counties	37,342,978
Tidioute district, including Economites, Henderson farm, etc	4,674,345
Clarion district, including Clarion county	20,381,638
Bradford district, including McKean and Elk counties; also Cattaraugus and Allegany counties, New York	44,574,921
Bullion district, including Venango county	2,312,190
Warren division, including Stoneham, Clarendon, etc	448,213
Beaver division, including Smith's Ferry, etc	339,631
Total production from all districts	156,890,331

STATEMENT, BY COUNTIES, OF THE NUMBER OF ACRES DEVELOPED IN THE OIL-FIELDS OF PENNSYLVANIA AND NEW YORK FROM AUGUST 26, 1859, TO DECEMBER 31, 1880.

State and county.	Number of acres.
Total	156, 380
Venango county, Pennsylvania	32, 000
Crawford county, Pennsylvania	6, 400
Forest county, Pennsylvania	1, 920
Warren county, Pennsylvania	6, 720
Armstrong county, Pennsylvania	5, 120
Clarion county, Pennsylvania	19, 200
Butler county, Pennsylvania	27, 520
McKean county, Pennsylvania	50, 000
Cattaraugus county, New York	7, 500

STATEMENT MADE BY THE UNITED PIPE-LINES FROM THE BEGINNING OF APRIL, 1877, TO JULY 9, 1881.

Month.	Gross stocks.	Sediment and surplus.	Net stocks.	Outstanding acceptances.	Credit balances.	Receipts from all sources.	Total deliveries.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
1877.							
April	1, 895, 153. 71	77, 386. 70	1, 817, 767. 01	449, 640. 14	1, 368, 126. 87	200, 570. 81	125, 797. 90
May	1, 762, 602. 64	75, 364. 87	1, 687, 237. 77	683, 663. 71	1, 003, 574. 06	493, 200. 58	619, 612. 26
June	1, 569, 367. 68	81, 255. 42	1, 488, 112. 26	661, 786. 57	826, 325. 69	538, 906. 95	737, 609. 77
July	1, 482, 433. 51	81, 741. 50	1, 400, 692. 01	667, 166. 36	733, 525. 65	615, 145. 46	699, 476. 18
August	1, 489, 052. 53	81, 144. 63	1, 407, 907. 90	643, 281. 46	764, 626. 44	673, 403. 04	666, 144. 28
September	1, 339, 032. 27	67, 163. 68	1, 271, 868. 59	552, 676. 26	719, 192. 33	624, 225. 37	760, 745. 57
October	1, 434, 728. 78	46, 771. 99	1, 387, 956. 79	673, 850. 05	714, 106. 74	687, 094. 59	570, 092. 71
November	1, 691, 399. 52	39, 418. 00	1, 651, 981. 52	657, 591. 36	994, 390. 16	913, 644. 16	649, 242. 70
December	2, 830, 415. 36	68, 729. 63	2, 761, 685. 73	754, 338. 25	2, 007, 347. 48	1, 656, 150. 37	506, 322. 99
1878.							
January	3, 124, 641. 15	72, 453. 43	3, 052, 187. 72	864, 711. 41	2, 187, 476. 31	972, 681. 18	715, 149. 78
February	3, 439, 526. 98	82, 452. 66	3, 357, 074. 32	1, 404, 292. 13	1, 952, 782. 19	1, 030, 688. 44	720, 478. 14
March	3, 940, 000. 65	92, 963. 06	3, 847, 037. 59	1, 487, 439. 50	2, 359, 598. 09	1, 196, 251. 26	701, 681. 27
April	4, 335, 274. 84	133, 934. 76	4, 201, 340. 08	1, 615, 791. 10	2, 585, 548. 89	1, 137, 359. 40	778, 050. 53
May	4, 609, 681. 45	150, 117. 76	4, 459, 563. 69	2, 065, 333. 31	2, 394, 230. 38	1, 104, 352. 40	843, 081. 33
June	4, 719, 699. 25	181, 800. 03	4, 537, 899. 22	1, 950, 420. 81	2, 587, 478. 41	1, 092, 604. 02	1, 004, 474. 55
July	4, 885, 851. 72	229, 080. 78	4, 656, 770. 94	2, 078, 469. 56	2, 578, 301. 38	1, 258, 648. 45	1, 108, 074. 33
August	4, 571, 658. 59	217, 085. 19	4, 354, 573. 40	2, 064, 590. 76	2, 289, 982. 64	1, 195, 268. 67	1, 496, 009. 04
September	4, 410, 061. 84	225, 088. 86	4, 184, 972. 98	1, 705, 853. 05	2, 479, 119. 03	1, 182, 118. 57	1, 318, 265. 33
October	4, 072, 627. 43	234, 050. 89	3, 838, 576. 54	1, 517, 484. 27	2, 321, 092. 27	1, 271, 174. 73	1, 564, 984. 43
November	4, 083, 972. 42	216, 655. 30	3, 867, 317. 12	1, 784, 443. 35	2, 082, 873. 77	1, 159, 623. 71	1, 129, 047. 02
December	4, 098, 200. 92	201, 470. 30	3, 896, 730. 62	1, 741, 311. 07	2, 155, 419. 55	972, 338. 83	924, 035. 93
1879.							
January	4, 759, 031. 41	182, 707. 80	4, 576, 323. 61	2, 153, 763. 83	2, 422, 559. 78	1, 231, 237. 19	546, 271. 74
February	5, 157, 646. 15	171, 689. 80	4, 985, 956. 35	2, 346, 238. 22	2, 639, 718. 13	1, 055, 377. 95	633, 828. 71
March	5, 503, 768. 71	190, 797. 91	5, 312, 970. 80	2, 484, 881. 83	2, 828, 088. 97	1, 363, 512. 17	1, 029, 029. 70
April	5, 885, 675. 24	211, 957. 06	5, 673, 718. 18	2, 644, 301. 36	3, 029, 416. 82	1, 379, 349. 76	1, 015, 482. 04
May	6, 180, 843. 53	315, 992. 98	5, 864, 850. 55	2, 522, 486. 36	3, 342, 364. 19	1, 488, 514. 31	1, 228, 043. 27
June	6, 426, 802. 45	334, 457. 29	6, 092, 345. 16	2, 959, 921. 12	3, 132, 424. 04	1, 437, 250. 90	1, 204, 757. 54
July	6, 419, 699. 08	323, 295. 32	6, 096, 403. 76	3, 323, 575. 29	2, 772, 828. 47	1, 472, 651. 01	1, 465, 518. 05
August	6, 380, 606. 63	302, 345. 15	6, 078, 261. 48	3, 581, 224. 03	2, 497, 037. 45	1, 714, 620. 11	1, 728, 940. 81
September	6, 589, 859. 83	325, 363. 85	6, 264, 495. 98	3, 783, 480. 38	2, 481, 015. 60	1, 691, 863. 41	1, 455, 811. 45
October	6, 701, 209. 87	299, 393. 67	6, 401, 816. 20	3, 788, 155. 65	2, 613, 660. 55	1, 646, 725. 06	1, 502, 991. 20
November	6, 951, 133. 67	303, 641. 17	6, 647, 492. 50	3, 972, 300. 18	2, 675, 192. 32	1, 600, 961. 29	1, 328, 621. 19
December	7, 362, 409. 76	294, 571. 37	7, 067, 838. 39	4, 235, 459. 40	2, 832, 378. 99	1, 771, 781. 24	1, 331, 822. 12
1880.							
January	7, 735, 257. 38	295, 517. 60	7, 439, 739. 78	4, 436, 788. 55	3, 002, 951. 23	1, 832, 963. 04	1, 455, 194. 98
February	8, 187, 012. 49	322, 568. 93	7, 864, 443. 56	4, 602, 286. 49	3, 262, 157. 07	1, 607, 663. 89	1, 178, 111. 92
March	8, 621, 097. 49	351, 130. 35	8, 269, 967. 14	4, 811, 894. 33	3, 458, 072. 81	1, 815, 133. 31	1, 396, 037. 88
April	9, 662, 354. 59	388, 558. 16	9, 273, 796. 43	5, 846, 536. 60	3, 427, 259. 83	1, 739, 297. 37	723, 794. 73
May	10, 306, 078. 79	454, 193. 73	9, 851, 885. 06	6, 361, 320. 05	3, 490, 565. 01	1, 552, 240. 91	975, 061. 26
June	11, 266, 771. 77	477, 431. 69	10, 789, 340. 08	7, 397, 131. 89	3, 392, 208. 19	1, 781, 937. 29	848, 339. 08
July	12, 039, 010. 00	475, 446. 56	11, 563, 563. 44	8, 125, 241. 25	3, 438, 322. 19	1, 890, 161. 44	1, 095, 528. 25
August	12, 749, 623. 28	462, 987. 28	12, 286, 636. 00	8, 635, 394. 80	3, 651, 241. 20	1, 904, 452. 70	1, 177, 448. 42
September	13, 618, 726. 03	382, 398. 71	13, 236, 327. 32	9, 287, 193. 94	3, 949, 133. 38	2, 075, 105. 26	1, 115, 184. 71
October	14, 020, 877. 39	391, 331. 55	13, 629, 545. 84	9, 448, 615. 77	4, 180, 930. 07	1, 999, 487. 98	1, 498, 285. 06
November	14, 656, 891. 55	341, 262. 67	14, 315, 628. 88	10, 083, 824. 08	4, 231, 804. 80	1, 859, 991. 50	1, 064, 146. 39
December	15, 369, 758. 67	361, 184. 83	15, 008, 573. 84	10, 913, 283. 49	4, 095, 290. 35	1, 987, 283. 54	1, 207, 928. 35
1881.							
January	16, 291, 307. 87	360, 688. 98	15, 930, 618. 89	11, 672, 583. 61	4, 258, 035. 28	1, 876, 526. 50	931, 718. 71
February	17, 355, 485. 31	391, 616. 47	16, 963, 868. 84	12, 029, 594. 35	4, 934, 274. 49	1, 823, 713. 46	781, 747. 93
March	18, 488, 476. 94	432, 304. 19	18, 056, 172. 75	13, 099, 262. 44	4, 956, 910. 31	2, 222, 812. 39	1, 116, 695. 11
April	19, 560, 752. 23	517, 422. 38	19, 043, 329. 85	13, 846, 285. 20	5, 197, 044. 65	2, 182, 636. 96	1, 183, 779. 02
May	20, 501, 117. 33	640, 662. 03	19, 950, 455. 30	14, 608, 124. 70	5, 342, 330. 60	2, 278, 582. 78	1, 356, 688. 23
June	21, 397, 698. 53	756, 412. 85	20, 641, 285. 68	14, 738, 828. 77	5, 902, 456. 91	2, 318, 445. 18	1, 545, 448. 13

The above figures are in barrels of forty-two gallons each.

MISCELLANEOUS PIPE-LINE STATISTICS FOR 1879 AND 1880.

Month.	Daily average of charters.		Average daily runs by all lines.		Stocks in pipe-line tanks.		Tide-water.			
							Runs.		Shipments.	
	1879.	1880.	1879.	1880.	1879.	1880.	1879.	1880.	1879.	1880.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
Average for the census year...	32, 377	....	61, 837	....	8, 323, 681	....	203, 378	....	179, 409	....
January	14, 800	18, 303	45, 710	67, 330	5, 064, 693	8, 520, 696	65, 026	154, 034	216	118, 400
February	12, 200	20, 822	43, 105	62, 671	5, 541, 683	8, 930, 508	52, 182	125, 376	492	716, 057
March	27, 700	18, 954	48, 856	67, 024	5, 928, 628	9, 369, 240	55, 421	167, 564	37	741, 062
April	26, 000	18, 975	50, 754	67, 921	6, 332, 841	10, 545, 425	53, 477	199, 327	2, 585	34, 162
May	32, 800	18, 370	52, 963	59, 048	6, 565, 454	11, 230, 883	55, 489	905, 153	36, 728	88, 836
June	49, 000	36, 735	53, 908	69, 931	6, 849, 389	12, 281, 711	82, 035	230, 089	35, 575	94, 398
July	36, 000	35, 033	54, 061	71, 072	6, 938, 690	13, 150, 974	108, 020	210, 178	24, 588	94, 095
August	38, 600	30, 916	61, 886	71, 010	6, 998, 046	13, 945, 113	107, 402	196, 249	40, 680	85, 482
September	47, 300	33, 567	63, 504	67, 813	7, 328, 980	14, 713, 346	121, 303	169, 147	58, 054	97, 493
October	44, 700	18, 231	60, 694	70, 861	7, 402, 630	15, 114, 802	139, 883	185, 551	98, 889	129, 178
November	46, 300	21, 730	60, 278	65, 709	7, 675, 193	16, 756, 954	118, 092	162, 269	97, 366	121, 978
December	31, 300	21, 500	63, 722	57, 749	8, 094, 496	16, 616, 628	114, 352	173, 125	99, 243	110, 659

SECTION 8.—THE PRODUCTION OF THE PACIFIC COAST.

Concerning the petroleum production of the Pacific coast, I have to say that I have no official returns from any of the parties interested, no communication addressed to them having elicited any response whatever, and in consequence I have been forced to rely on such other sources of information as were available. My own experience in relation to the petroleum of that region led me to accept all reports published in the newspapers with great caution I addressed a letter of inquiry to the senior member of a firm long engaged in trade in refined oils upon the San Francisco market, and received the following reply, dated March 16, 1882:

The consumption of this coast of eastern oils is 4,500,000 gallons of refined. The product of all the refineries of this coast does not exceed 400,000 gallons refined. It is of inferior quality, low test, and is principally sold to the Chinese trade at about 16 cents per gallon in cans, or less, by 6 cents per gallon, than the cheapest eastern oils. In addition, about 400,000 gallons of crude oil is sold here for making gas and fuel. The production seems to be decreasing, the wells being, as a rule, short-lived. The above is, I consider, reliable, and is the best information I can get. My firm sell considerable oil, both high- and low-test eastern. We have no demand for California production.

Mr. J. C. Welch, in his report for February, 1880, says:

My California correspondent writes, February 2, as follows: "In reference to the Californian production, I would state that since my last letter there has nothing new been developed. It is very expensive and very difficult to drill wells in California, owing to the angle at which the rock stands, causing it to cave from the top to the bottom of the well. It requires four or five sizes of casing, telescoped from 12 inches to the smallest size that can be drilled through. In this way it requires about as much capital to case a well here as the entire expense of a well in Pennsylvania. The time required to drill is from three months to two years, it being very difficult to get the casing down, the rock caving at every point. However, these obstacles would all be overcome if there was a class of men like Pennsylvania producers in this country to drill wells, but, fortunately for the producing interests of the United States, the monopoly in California is in the producing interest instead of in the refining and transportation interest, as in Pennsylvania. A syndicate of millionaires, led by C. N. Felton (who was first in the development of the Bonanza mines of Nevada), have been busily engaged for the last two years in purchasing in fee all the lands that show any indications of being oil territory, which, as the tracts of land in which the oil district is located were originally divided by the old Spanish grants containing hundreds of thousands of acres, it has been a comparatively easy matter for them to do, and they seem inclined to keep their oil in the ground until such times as Pennsylvania shall have exhausted her supplies and the product here is needed for the world's demand. Although the same company have obtained all the necessary machinery, iron, and fixtures for the refinery (of which I wrote you recently), and have land secured in a favorable location, located on the bay and also connected with both systems of railroad, narrow and broad gauge, yet they have not actually commenced the erection of the works. It will require about ninety days from the time they break ground until the refinery can be completed.

As I suggested in my former letter to you, these parties at present do not intend to produce more oil than is required for the Pacific coast trade, and for the next two or three years the California territory need have no influence whatever on the general petroleum market unless some unexpected strike should be made that now seems unlikely, as there are only two or three wells being drilled.

I do not know exactly what percentage of refined oil is obtained from California crude; but should not, from my experience, place the production at above 1,000,000 gallons, or 2,500 barrels. 100,000

SECTION 9.—THE FOREIGN PRODUCTION OF PETROLEUM IN COMPETITION WITH THE UNITED STATES.

From various reports that have received my attention in reference to this subject I select the following as most entitled to confidence. The first which I offer, reviewing all of the European fields upon observations made during the census year, is from the February (1880) report of Mr. J. C. Welch. The second paper was prepared expressly for this report by William Brough, esq., of Franklin, Pennsylvania, a gentleman of large experience in the Pennsylvania oil regions, whose opinions are based upon a careful personal inspection of the Russian petroleum fields, they being really the only European fields likely to prove of more than local importance. Mr. Welch, in his report on Russia, says:

The various oil territories of the world have, during the past year, been receiving some attention, and the chance of their supplying oil to meet more or less of the world's needs is of course an important one to those whose interests are principally identified with that supply being drawn from western Pennsylvania. The Russian territory on the Caspian sea has received the most attention, and it has a prolific yield; the two things that have militated chiefly against its being a competitor of importance of the Pennsylvania petroleum are in the character of the oil, only yielding about 33 per cent. of illuminating oil, and in the difficulty of getting it to the markets of the world through inadequate means of transportation. The opinion prevails among some that a percentage of illuminating oil can be got from it as great as that obtained from American petroleum, requiring, however, some different process of refining. This plan is to be tested soon by the erection of a refinery in Russia, the owners having sufficient confidence in their process to erect a refinery of sufficient size to be a complete test as to whether the process will be a success or not.

Mr. L. Emery, jr., a well-known resident and producer of this region, has just returned from the Baku field, after having taken time to give it a critical examination. He estimates the production there during the past year to have been about 28,000 American barrels per day from 78 wells, showing the extraordinary average of 360 barrels. The depth of the wells is only about 500 feet. There were shipped from Baku last season about 1,230,000 gallons of refined oil. Oil is refined at Baku at 195 refineries, with a charging capacity of 28,000 American barrels. There are now in course of erection stills with a charging capacity of about 2,000 barrels, which will be ready for business with the opening of navigation in the spring. Some of these refineries are very small; others are owned by independent corporations with large capital. From Baku oil is sent east, south, and west by canals and wagons, and by the Volga river to Kisan, and thence by cars it reaches the principal markets of Russia.

Mr. Emery says it is estimated there are 25,000,000 poods (about 3,125,000 barrels) of crude oil in the vicinity of Baku held in excavations in the ground or lakes. Pipe-lines are being used from the wells to the refineries in the vicinity of Baku, a distance of 6 miles. Two 3-inch lines have recently been laid, one with pipes of American and one of English manufacture; and three more pipe-lines are in process of construction, one of 5 inches diameter, the other two of 3 inches diameter. A railroad also runs through the district. The price paid for pipeage is about 8 cents per American barrel, and oil is now a drug at 6 cents a barrel at the wells.

Petroleum is found more or less on both sides of the Caucasian mountains; and oil is produced within the city limits of Tiflis, a city which is rated by the latest census as having 70,591 inhabitants. A railroad is in operation from the Black sea to Tiflis, a distance of 180 miles, and is in process of construction from Tiflis to Baku. Eighteen miles of this is already built, its construction having commenced last summer. The contract calls for its completion within three years of its commencement, with a forfeiture for every day over that time that it is not completed The contractor, however, states his expectation of completing the road within eighteen months from the beginning. The Russian government is the chief mover in the construction of the road, and the road is being built by a government contractor of large means.

In this railroad, and in the possibility of a process of refining oil by which an increased percentage of illuminating oil can be eliminated, rests an apparent danger to the petroleum business of western Pennsylvania. With this railroad completed the Baku oil would be placed on tide-water navigation with a railroad haul of nearly 600 miles. The commerce of the Black sea is already very important, Odessa, located upon it, being one of the great grain markets of the world.

Very considerable attention is now being turned toward territory in Europe that presents some aspects of being oil-bearing. The country south of the Caucasian mountains, of which Tiflis is the center, while belonging to Russia, is in Asia. Immediately north of the Caucasian mountains is the Kouban river, emptying into the Black sea.

The following is from my New York daily report of March 12:

"I have recently come more fully in contact with people having knowledge of the oil-producing territory on the Caspian sea than I had at the time of writing my February monthly report, and I now find the statement I made in that report is of much too favorable a character in regard to Baku production and getting the Baku oil to market. The railroad I spoke of as being constructed between the Black and Caspian seas has been constructed for some time from the Black sea to Tiflis, and a short piece has been built, say 12 miles long, on the Baku end, in the vicinity of the oil-wells. It is intended to go to work on the road east of Tiflis soon, but operations have not yet commenced, or had not recently. This distance is between 300 and 400 miles, and there are some uncertainties concerning its construction which may keep it delayed for a long time. I am informed by merchants in this city, who have correspondents in that vicinity, that my information is at fault very considerably regarding the amount of production at Baku, and that it is very much less. Taking into consideration what I am recently informed, the matters at Baku are not of a nature, I judge, that require them at present to be taken into account as having a bearing upon the prices of American petroleum."

Dr. Tweddle, formerly of Pittsburgh and Franklin, representing a French company, is drilling two wells upon this river, and has a small refinery at Taman, a city located near the mouth of the Kouban. He has secured enormous tracts of territory from the Russian government. Five drillers and experienced well-men recently left Oil City to join Dr. Tweddle on the Kouban river. Mr. James R. Adams, of Oil City, experienced in oil matters, has been with Dr. Tweddle since last summer, having previously spent a year at Baku.

The following is Mr. Welch's report on Galicia and Germany:

Galicia, in Austria, has been producing some oil for a considerable time, and has now a production of about 500 barrels per day. This territory has been visited by Americans accustomed to drilling wells and refining oil, who had gone to inspect it, with a view of doing business there, and they came away unfavorably impressed with it as a place to locate in the oil business. Drilling is difficult and expensive there, the strata of the rocks not lying horizontally, but being at an angle that causes them to cave after being drilled through. Much or most of the oil is taken from near the surface from wells dug down, and the oil then bailed out. The oil is unreliable in gravity even at considerable depths, and the heavier grades are a drug, not being treated in such a way as to make a satisfactory lubricating oil. The Galician field is situated on the north side of the Carpathian mountains, and extends a distance of about 200 miles, with a width of about 10 miles. In Hungary, on the south side of the Carpathian mountains, there are the same indications of oil that there are on the north side. An English-American company has secured 29 square miles here, and are now taking steps to operate it.

There have been numerous cable reports published in the newspapers recently of oil discovered in Hanover, Germany. European petroleum circulars I have received since these reports were circulated make no mention of them, and I have as yet heard nothing from my European correspondents upon the subject, although I cabled Bremen about it, and it consequently appears to me that the European petroleum trade is not taking much notice of these reports.

Some petroleum has been found not far from Bremen for the past two hundred years. While I was in Bremen one year ago I took some notes of what gentlemen I met hoped would prove to be an oil district. It is located 128 English miles southeast of Bremen. They had three wells then down, of different depths, as follows: 181, 242, and 680 feet. Of the first two they were getting a small quantity of oil, one yielding 5 and the other 30 per cent. of illuminating oil. The other well they were then beginning to test. I am informed since that it only produces a barrel and a quarter per day, and that it is of heavy gravity. These wells are near the small city of Peine. Wells recently cabled about to the newspapers are near Heide, in the northwestern portion of Holstein.

The following is William Brough's description of the Russian oil-belt:

The Russian "oil belt" may be traced, at intervals more or less remote, from the island of Schily-Khany, near the eastern shore of the Caspian sea, westward over the promontory of Apscheron, and following the line of the Caucasian mountains into the valley of the river Kouban, which empties its waters through a lagoon into the Black sea; thence it may be traced in the same general direction across the Crimea and to the oil-fields of Galicia, in Austria. This belt is actively worked in the Crimea, in the valley of the Kouban, and on the promontory of Apscheron, near the city of Baku; it is only at the latter point, however, that the product is sufficiently large to induce the gathering of statistics. At all other points the petroleum produced, whether gathered from springs or obtained by well-boring, is entirely absorbed by local consumption.

The following table gives the shipments of petroleum and its products from Baku for the years named, in barrels of forty gallons each:

Year.	Refined.	Residuum.	Crude.
1876	392, 977	150, 021	22, 137
1877	561, 236	232, 782	17, 169
1878	750, 218	388, 042	24, 699
1879	828, 347	755, 688	38, 628
1880, to July 1	376, 736	427, 053	24, 470

As the average yield of refined petroleum from Apscheron crude is about one-third, we may estimate the total crude product of that field for the year 1879 at 2,500,000 barrels, or 6,850 barrels per day. This oil is all consumed in Russia, a very little manufactured for lubricating excepted. The residuum is used for fuel, and is consumed nearly altogether by the steam vessels on the Caspian sea and the Volga river.

As shown by the table, the product of the Apscheron field declined about 9 per cent. in the first half of the year 1880, and by the end of that year the decline was so serious that the price, which had ruled for two years with little variation at 24 cents per barrel, advanced in the autumn to between $1 and $2 per barrel; but in 1881 production was so increased that in August the price had fallen to 2 copecks per pood for oil at the wells, equal to 8 cents per barrel of 40 gallons.

The Apscheron oil-field as at present worked lies within a radius of 20 miles of the city of Baku, but nine-tenths of the total product has so far been obtained from the deposit at Balachany, which covers an area of from 2,000 to 3,000 acres. This deposit has proved very rich. The oil is found in a loose, open sand, at a depth varying from 120 to 450 feet, and is brought to the surface in balers having check-valves in the bottom similar to the sand-pump used in the Pennsylvanian oil regions, the large amount of loose sand which comes up with the oil preventing the use of the ordinary suction-valve pump used in American wells. The largest well ever found in the Balachany district had been producing for six years in 1879, and had yielded during that time an average of 1,200 barrels per day—a production much in excess of that of any Pennsylvanian well. The diameter of the wells is from 8 to 12 inches; the capacity of the balers from 20 to 40 gallons. There are about 400 wells in the entire Apscheron district, the largest outside of Balachany giving about 10 barrels per day, and the average yield of the whole number, including Balachany, being about 20 barrels per day.

Balachany is situated 12 miles north of Baku, and is connected with it by a railway. There are also two pipe-lines for the transportation of oil to the latter place, where the refineries are mainly situated, and which is the port of shipment. There is one other pipe-line from Balachany to Soorachany, 5 or 6 miles distant, and 10 miles northeast of Baku. At Soorachany a large refinery is located, in order to utilize as fuel the gas from gas-springs there; there, too, may still be seen an ancient temple of the fire-worshipers, where prayers are daily said to a jet of petroleum gas, whose flame is never permitted to expire.

The development of the Apscheron oil-field has constantly been restricted by want of transportation facilities, the only outlet for the production from Baku to the markets of Russia being by way of the Caspian sea and the Volga river. Beside this new business of petroleum, now thirteen years established, the general commerce of the Caspian has in the same time been steadily growing, and the number of sea-going vessels, though constantly increasing, is still quite inadequate to supply the demand for transportation. In 1878 there were 30 steamships plying this sea; and of these 12 were imperial, leaving 18 merchant ships, varying in size from 300 to 500 tons. Eleven more were added in 1879, making 29 merchant steamships in all. There are beside numerous sailing-vessels. The steamships are all of foreign build, mainly English, and having to pass through the canals connecting the Baltic with the Volga, their size is consequently limited thereby. Some of them have been floated through in two sections. As the depth of water in the delta of the Volga is ordinarily but 2 feet, it is only in the spring of the year, when the water is 9 feet deep there, that these vessels can enter the Caspian. The oil, both crude and refined, is conveyed by these vessels in bulk compartments, as well as in casks and barrels, steamers being used almost exclusively for refined and sailing-vessels for crude and for residuum. The voyage is made from Baku to "nine-foot" water, where the vessels anchor in open roads and deliver their cargoes to barges built expressly for the shallow waters of the delta. These barges convey the oil to Astrakhan, a distance of 330 miles.

At Tzaritzin the facilities for unloading the barges, for storing oil, or delivering it to the railroad are modern in character, and are really copied from the American methods. They consist of pipes, pumps, and large iron storage-tanks. The railroad also is equipped with iron tank-cars similar to the American. Farther up the Volga the railway again connects with the river at Saratov, at Syzran, and at Nijni-Novgorod, to all of which oil is shipped, the last named being the most northerly point of river shipment, and 1,400 miles from Astrakhan.

In January, 1880, the Russian government granted a concession for the building of a railroad between Baku and Tiflis, the capital of the Caucasus, which was already connected by rail with Poti, on the Black sea. When this road shall be completed, it will furnish an outlet for Baku oil to the markets of Europe, and will bring it into direct competition with American oil in those markets The work of building this road is, if measured by the Russian standard, progressing rapidly. In August, 1881, 120 versts (about 80 miles) between Baku and Adji-Kabul was finished and in running order, and it is expected that the whole road will be completed by August, 1882. Its oil-car equipment will have capacity to deliver at the Black sea 1,000,000 barrels per year. As the harbor of Poti is exposed and unsafe, the railway will be extended 60 miles farther south to Batoum, recently ceded by Turkey to Russia, and the best harbor on the Black sea. The whole length of the railway will be 660 miles. The freight rate is uniform on all the railroads of Russia, being prescribed by the imperial government, and in 1879 was for petroleum 1 copeck per pood for 45 versts, or $9\frac{1}{4}$ mills for carrying one ton of 2,000 pounds 1 mile. At this rate the cost of transferring a barrel of petroleum from Baku to Batoum will be 88 cents.

As the petroleum product of Apscheron has thus far been so steadily maintained above the carrying capacity of the vessels on the Caspian sea, we need not doubt that, with the opening of the Baku and Tiflis railroad, other deposits will be found along the line indicated. Indeed, the Russian oil man is fully alive to this conception, and is already prospecting along the whole line from Baku to Adji-Kabul, buying and selling, leasing and releasing, oil lands after the manner of his American prototype. But until this railroad is completed the Americans need not fear competition from that quarter. The high rates of freight on the Caspian, the delays and hazard attending the discharge of cargo in open sea at "Nine-foot", the double transfer, and the long voyage from "Nine-foot" to Tzaritzin, requiring the service of steam-tugs all the way, these, added to the fact that this only outlet is closed by ice from November until April, form a complete bar to such competition. Indeed, it is doubtful whether the Russian could now hold his place in his own market without the help of the duty imposed for his protection upon American petroleum. This duty is 9 cents per gallon, payable in gold.

The gravity of Baku oil ranges from 26° to 36° B., there being very little of the latter grade, and the gravity of oil taken from pipe-line tanks, where the product of different wells is mixed, is about 30° B. This mixed oil gives a yield of 33 per cent. illuminating oil, and the residuum is used for fuel. No other fuel is used by steamers on the Caspian sea. Many of the steamers on the Volga also use it. It is also the only fuel used by the locomotives on the railway now building and partly completed from the eastern shore of the Caspian sea into the Turkoman territory recently acquired by Russia.

The oil-fields of the Kouban valley and the peninsula of the Taman, on the Black sea, have been worked actively, with some intervals of comparative rest, since 1864. In that year a Russian nobleman, Count Novosiltzoff, leased 1,500,000 acres from the "Cossacks of the Kouban" and began operations on an extensive scale. He employed American workmen, and extended his well-drilling over a stretch of country 150 miles in length. He also built a large refinery at Taman, on the straits of Enikale, near the western end of his territory. It is difficult now to ascertain what success attended his operations. At one point, Kudokko, it is said he obtained a very large well, some Cossack estimates putting it at 10,000 barrels per day; but we may rest assured that this is a greatly exaggerated statement. It may be doubted whether the well produced at any time 1,000 barrels per day, or for any considerable time even a hundred, for Novosiltzoff failed to obtain oil enough from his wells to compensate him for his expenditures, notwithstanding that the price ruled very much higher then than now; and his enterprise finally failed, after sinking his original capital and involving him in an indebtedness of about 1,500,000 rubles. The Kudokko well is still producing; its yield in 1878 was about 23 barrels per day. The well was then four years old. It is pumped by steam-power, with a suction-valve pump. The oil is of good quality, olive-green in color, gravity 36° B., and yields when distilled 50 per cent. of illuminating oil. A small refinery on the estate works up the oil into lubricants and illuminants, and finds ready sale for the entire product in the Cossack community of the neighborhood. Twenty-eight other wells were drilled around this first well without increasing the total product; indeed, the Kudokko oil-field has been shrinking steadily since it was first opened, notwithstanding the occasional drilling of new wells, and its total product is now less than 20 barrels per day.

In 1879 a French company, under American management, leased all the Novosiltzoff land except the 25,000 acres which form the Kudokko estate, and began operations in a vigorous manner. This company is still at work; it has in its employ skilled, practical workmen from the oil regions of Pennsylvania, and it has made several large shipments of well machinery from America. It also recently purchased here pipe and pumps for a pipe-line from Ilsky, where its most productive wells are situated, to the port of Novorossisk, on the Black sea, 65 miles west of Ilsky. It is perhaps too soon to determine what success in finding oil will attend its operations; but the total yield of its wells is thus far about 80 barrels per day, and the greater part of this product is of inferior character, being a black bituminous oil. It may, however, be doubted whether any large deposit of petroleum will ever be formed within the limits of this field, taking Ilsky as its eastern boundary and including all the land westward which forms the peninsula of Taman, bounded on the north by the sea of Azov and the straits of Enikale and on the south by the Black sea. There has been a large amount of unsuccessful test-drilling done here in the last sixteen years, but no rock has yet been found which makes a suitable receptacle for petroleum. Wherever found, the oil is diffused through the whole strata of soil and near the surface, so that no mechanical ingenuity is required to reach it, but it can be obtained with the rudest well-boring implements. It is therefore reasonable to conclude that the country has been worked for oil from remote times.

The greatest depth at which oil has been found here is 400 feet, and deeper drilling has thus far given no promise of success. These remarks are equally applicable to the Crimean district, which is of the same character.

Although illuminating oils manufactured in Russia from the native crude product compare favorably with the American oils, the latter have nevertheless been yearly imported into Russia, though in diminishing quantity; but the fact that these imports still continue seems to need some explanation, in view of the heavy duty of 9 cents per gallon imposed on American oil. A comparison of the burning qualities of the two oils shows that the American gives a slightly whiter flame, and that it is less liable to smoke than the Russian. In odor and color they are equal. The Russian oil burns with undiminished flame until the oil in the lamp is exhausted, while the flame of the American sinks when the oil becomes low in the lamps. The fire-test of the Russian oil is quite as good as of the best American, and the tendency to smoke of the Russian is easily overcome by a proper adjustment of the lamp-chimney.

The Russians have lately introduced some new patterns of chimneys.

These remarks apply only to standard oils of both countries found in open market at St. Petersburg, rejecting special brands and inferior or defective lots.

The following table gives the imports of American refined petroleum into Russia for the years named, the figures being taken from Russian official records and transposed from "poods" into barrels of forty gallons each:

	Barrels.		Barrels.		Barrels.
1867	68,316	1872	203,901	1877	261,780
1868	111,424	1873	379,481	1878	251,227
1869	158,137	1874	310,981	1879	188,752
1870	198,386	1875	308,225	1880	143,154
1871	217,555	1876	277,671		

In conversation with Mr. Charles H. Trask, of the firm of William Ropes & Co., of 70 Wall street, New York, largely engaged in the Russian trade, he remarked that transportation from Baku to St. Petersburg was so expensive that a high gold duty, augmented by a depreciated currency, alone rendered the manufacture of Russian oils in St. Petersburg possible. Without this duty the oils could not compete with American, although the lubricating oils made from Russian crude do not chill and are superior to American lubricating oils. He said, further, that shipments of low-grade American oils to Russia had entirely ceased, but that high-test American oils were still sold there. As the tariff may be changed at any time, the business was somewhat uncertain both for those within and those outside Russia.

I have not been able to obtain any satisfactory statistics of the Canadian production. So far as I can learn, stocks had accumulated in Canada before 1879, but during that year and subsequently these stocks were drawn down, so that the production of refined during the census year was no indication of the production out of the ground. I have not therefore made any attempt to estimate the Canadian production, which is only of local importance, as partially supplying the Dominion markets.